Methodical aspects of studying artificial intelligence by future teachers

Nataliya O. Kushnir[1,2], Nataliia V. Valko[1]

[1]*Kherson State University, 27 Universytetska St., Kherson, 73003, Ukraine*

[2]*1Bogdan Khmelnitsky Melitopol State Pedagogical University, 59 Naukovohomistechka Str., Zaporizhzhia, 69000, Ukraine*

Abstract

Presently, the advent of artificial intelligence has created a rift in society, with two distinct groups emerging: advocates who embrace the potential of AI to positively transform lives and skeptics who harbor concerns over its development, with the most alarming fear being the potential destruction of human civilization. Nevertheless, it is evident that artificial intelligence has permeated various facets of society, with an ever-expanding array of services relying on this technology. A noteworthy observation is that students and apprentices are increasingly engaging with AI-driven services, often without a complete grasp of its underlying principles, effective application, or potential risks. Consequently, it becomes crucial to equip future educators with sufficient expertise in this domain, enabling them to assist their students in safely and purposefully utilizing AI-based services to attain specific objectives. The article analyzes the research and recommendations concerning AI's integration in education. We highlight essential aspects that must be emphasized during the training of prospective teachers in the fundamentals of artificial intelligence. Additionally, various applications of AI within the educational process. are proposed. The suggested structure can serve as the foundation for a standalone module or be further expanded into a comprehensive educational discipline.

Keywords

Artificial Intelligence, teaching aids, machine learning, training of future teachers, cloud technologies, informational computer technologies (ICT), school, education, AI literacy, Pedagogical appropriateness, Teacher well-being

1. The phenomenon of artificial intelligence. How artificial intelligence is changing the life of society

In 2017, AlphaZero, powered by machine learning, defeated chess-playing computer programs that relied on established starting databases and endgame tables. This was the beginning of a real AI boom.

Until 2017, the field of artificial intelligence was considered just entertainment, a field of research and illiquid investments. However, since that moment, most innovative startups have

recognized the full potential and prospects of using such technologies. Research from Stanford's Department of Artificial Intelligence indicated that private capital investments in the field grew several-fold during the period of 2019-2020 [1]. This demonstrated that businesses were willing to invest money in this sector and, consequently, expected substantial returns.

Nevertheless, there have been gradual changes, and according to evaluations by the company Gartner [2], interest in AI is gradually waning. It is worth noting that the interest is transforming: from an intriguing toy capable of altering photos and voices, AI has transitioned into a category of tools that generate profits and minimize expenses. For the general public, it may currently appear as a disappointment, as AI does not know how to perform certain tasks well or at all. However, one of the largest technology exhibitions, Hannover Messe 2023 [3], showcased that artificial intelligence is already a common phenomenon in the presented products, machines, mechanisms, and concepts. The current challenge is to identify the problems that AI can solve. Marketing, market access, management, and business models are all crucial aspects needed for the development of AI applications at this stage.

Among the most common applications where AI models are used to solve problems, we can mention:

- Intelligent assistants (e.g., Siri and Alexa)
- Manufacturing and drone robotics
- Tools for disease prediction
- Optimized and personalized treatment recommendations
- Conversational assistants (bots) for marketing and customer service
- AI advisors for stock trading or personnel selection
- Spam filters in email
- Social media monitoring tools for identifying dangerous content or fake news
- Banking applications for fraud prevention in lending
- Song or TV show recommendations from Spotify and Netflix and other steaming services
- Traffic load analysis (vehicles or people)

Research in the field of artificial intelligence (AI) has been focused on understanding its positive and negative effects. In order to mitigate potential harm caused by AI, UNESCO developed Recommendations on AI Ethics in 2021 [4, 5]. These recommendations address ethical considerations and also emphasize the discussion on using AI to achieve Sustainable Development Goal 4 (Quality Education).

In 2021, the European Union launched an initiative to regulate AI. But after the popularization of ChatGPT, a project was already adopted in 2023, which will form the basis of the future law on the rules for regulating artificial intelligence (Proposal for a Regulation laying down harmonised rules on artificial intelligence). Among the main regulatory criteria is the level of risk to human rights and health. The list of high-risk areas includes artificial intelligence in education, critical infrastructure, public order, and migration management.

In Ukraine, a concept for the development of artificial intelligence in the country until 2030 has been approved [6]. The concept outlines several key directions, including:

- Enhancing middle and higher education and improving qualification programs to prepare skilled professionals in the field of AI.

- Stimulating scientific research in the field, including through grant programs.
- Promoting entrepreneurship in the AI sector and developing methods for retraining individuals whose jobs may be affected by automation within 5-10 years.

2. Impact on the education system

Researchers note that "at least for now, ChatGPT cannot replace human creativity and critical thinking, and it is through these advantages that higher education thrives" [7]. However, universities need to consider the current state of technological development, especially in areas such as AI, which already significantly impact the economy and social aspects of society.

In the process of education, students use services based on the use of artificial intelligence. Higher education institutions take one of two approaches to the question of students' use of AI [8]:

- Prohibit students from using AI.
- Attempt to regulate the processes of AI use.

For instance, in one of the institutions, during the assessment, students attempted to use AI. The examination revealed that, for the time being, this is not a widespread occurrence. However, the following measures were taken [9]:

- Informing Instructors: Educators were informed about potential cheating attempts involving AI.
- Establishing Clear Rules: Clear protocols were established for how the institution and teachers should handle this issue, particularly from a legal standpoint.

As one of the strategies, during knowledge evaluations conducted through oral interviews, the overall time allocated for presenting a topic and the time for questions/answers were increased.

Among the main issues and ethical consequences of using ChatGPT in higher education, researchers identify the following [8]:

- Academic integrity.
- Lack of regulation.
- Confidentiality.
- Cognitive bias.
- Gender and diversity.
- Accessibility.
- Commercialization.

However, in our opinion, familiarizing students with the possibilities of AI for their future professions, mastering new tools, understanding their advantages and disadvantages, and comprehending the trends of human development can significantly enhance the competitiveness of young professionals on the job market.

In the work [10], the authors recommend that supervisors use autonomy-supportive strategies for educators rather than control. This strategy enables "allowing for choices around planning and reducing unnecessary stress and demands on teachers. Teachers should make their own choices and decisions regarding the curriculum based on their self-efficacy and intended development, and in return, they feel empowered in planning".

We conducted a survey among teachers and students to assess how technology is impacting education. A total of 87 teachers and students participated in the survey. They answered the following questions:

- In your opinion, at what stage of implementation are the following technologies in SOCIETY?
- At what stage of study do you think the following technologies are in EDUCATION?

Respondents assessed the following technologies: Computer Technology, Mobile Technology, Cloud Technology, Robotics, Machine Learning, Artificial Intelligence, Augmented Reality, Virtual Reality. For each of these questions, respondents had options for answering the degree of implementation as follows: The stage has already been passed, At work, Study, Pilot stage, Planning, Has no chance.
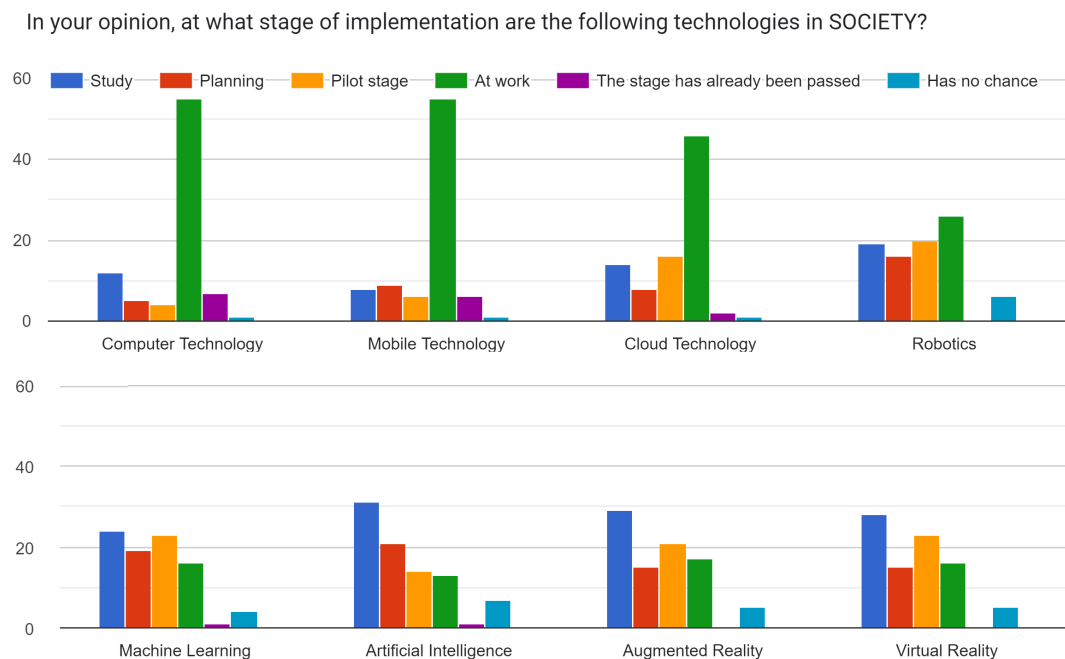

Figure 1: In your opinion, at what stage of implementation are the following technologies in SOCIETY?

The results of the survey are presented in figure 1 and figure 2. As we can see, both teachers and students recognize the importance of technology and the necessity of its incorporation into education. However, there is a need for the selection of appropriate resources and the
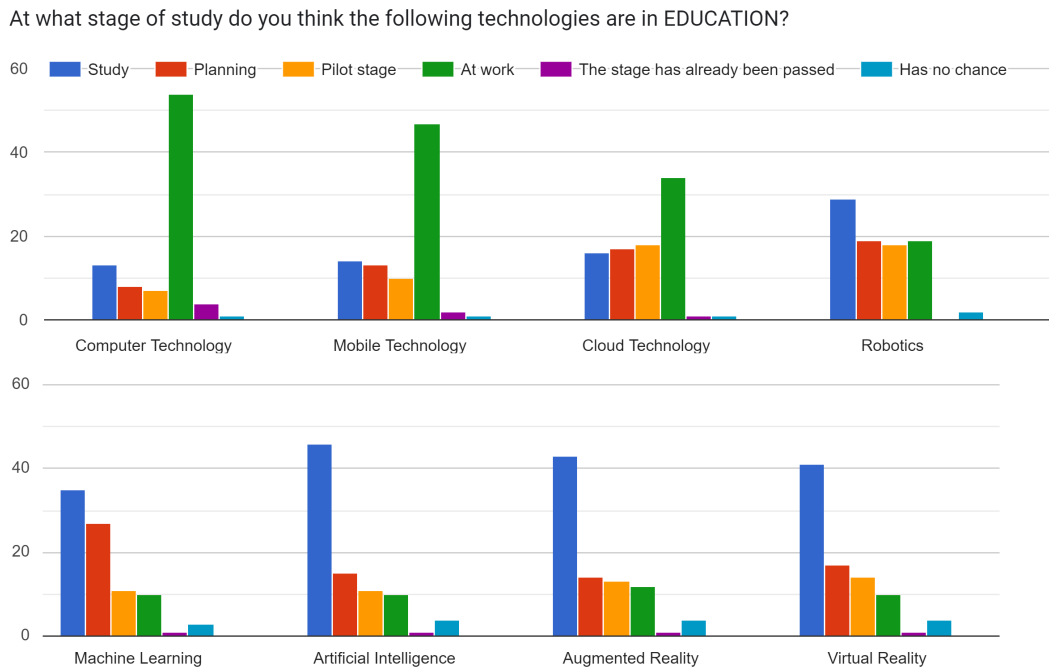
At what stage of study do you think the following technologies are in EDUCATION?

Figure 2: At what stage of study do you think the following technologies are in EDUCATION?

development of AI learning programs that would familiarize teachers with basic concepts, technologies, and examples of implementing AI education.

In global practice, there is already experience in teaching artificial intelligence in the school computer science curriculum. Examples include Chinese AI learning programs, as such courses are mandatory according to the national curriculum (Ministry of Education of The People's Republic of China 2022), which covers students from grades 1 to 9 [11].

This comprehensive AI course syllabus comprises 90 core concepts, 63 learning indicators, and 27 teaching and learning resources. It consists of 6 modules, the first four of which serve as the technical foundation for the subsequent ones. One of the advantages of this course is its cross-curricular nature, allowing for the integration of acquired knowledge in higher grades. Additionally, this program bridges AI programming and robotics.

The research by [10] authors indicates that in the development of such a course, educators should follow four main approaches to AI curriculum planning: content, product, process, and practice.

The authors propose a five-stage development cycle for teacher training programs:

- Preparation: Focuses on preparing teachers for curriculum pre-planning.
- Content and Product Design: Defines the knowledge and assessment criteria, as well as methods for the curriculum.
- Process and Practice Development: Develops instructional activities that encourage student engagement.

- Design and Development: Teachers design and develop curriculum materials based on the plan created in the previous two stages.
- Reinforcement: Teachers should be encouraged and supported in reviewing the curriculum for ongoing development.

The AI learning program described in the paper [12] incorporates active learning through project-based activities. It also addresses issues related to AI ethics, the societal consequences of its usage, and reducing accessibility barriers for all participants in the learning process.

It is important to foster a conscious attitude towards the use of AI technologies, including a recognition of potential risks, limitations, and possible errors in the information generated (information reliability). For example, Kozminski University (Poland) has developed the following recommendations for the responsible and ethical use of AI-based text, image, audio, and video generators like ChatGPT, for ethical and responsible use and development of knowledge for students and faculty:

- Openness to using digital tools, including ChatGPT, to support student development and reflective attitudes. This can be achieved through assignments, group projects, and in-class work aimed at enhancing critical thinking skills, fostering innovation, and identifying areas of application in academic and professional contexts. Sessions may involve discussions and creative utilization of technologies while accompanying the establishment of values.
- Permission to use tools like ChatGPT in the research process, emphasizing the independence of student activities and transparent use of technologies.
- Openness to using digital tools, including ChatGPT, to support student development and reflective attitudes. This can be achieved through assignments, group projects, and in-class work aimed at improving critical thinking skills, fostering innovation, and identifying areas of application in academic and professional contexts. The concept may involve discussions and collaborative value creation accompanied by creative technology use.
- Permission to use tools like ChatGPT in the research process, emphasizing the independence of student activities and transparent use of technologies. Content generated by ChatGPT is not considered content created independently by students.
- Preventing misuse by implementing random checks of written projects using plagiarism detection mechanisms.
- Systematically creating and expanding a knowledge base about ChatGPT and similar tools, as well as establishing a platform for sharing experiences to promote ethical use of these tools in the learning process and prevent abuse [13].

We consider strengthening the preparation of future teachers in this area to be particularly important because only a teacher who possesses these skills can effectively and safely teach students how to use AI. Today, universities have the opportunity to offer students the ability to shape their personal learning trajectory, including through the choice of topics for coursework, final projects, and elective courses. Additionally, the fundamentals of AI can be incorporated into certain teacher education programs.

Tasks that teachers face include:

- Translating AI tasks into terms and analogies that are accessible to specific age groups.
- Selecting appropriate tools.
- Developing educational materials and curricula.

Currently, there are already some educational materials available for learning the basics of AI. Notable examples include courses for students such as "Artificial Intelligence for Schoolchildren" by the Sokrat Educational Center (Kyiv), "Artificial Intelligence for Students in Grades 10-11" by Digital Education and UNICEF, "Machine Learning" on the Prometheus platform, "AI Fundamentals" by Google, and others [14, 15, 16, 17, 18].

It should be noted that the university offers educational programs related to artificial intelligence, but the vast majority relate to technical specialties. For example, the "Artificial Intelligence" undergraduate educational program is offered by the Kharkiv National University of Radio Electronics; State University information and communication technologies; "Artificial Intelligence Systems" Kyiv National University of Economics named after Vadym Hetman; "Data analytics and artificial intelligence" National Aviation University; the educational and scientific program "Artificial Intelligence Technologies" at the master's level of higher education is offered by Taras Shevchenko Kyiv National University; Separate blocks of subjects for the study of Artificial Intelligence are offered to students of other universities, mainly of a technical profile, such as Kharkiv National University named after V. N. Karazin, Odesa Polytechnic, Zaporizhzhya Polytechnic Institute, and others.

3. Experience of practicing teachers

Today, scientists and teachers in Ukraine are enthusiastically conducting research on the possibilities of using artificial intelligence in education. Among the teachers' developments analyzed by us, three training course programs developed by Serhiy Dzyuba (director of development of the STEM center "Socrates", deputy director of the educational and educational complex #141 "ORT") for middle school students, high school students and teachers deserve special attention . It should be noted that today teachers are offered a fairly wide range of professional development courses, which include the topics of security and the use of artificial intelligence in education. A convenient and useful tool for mastering artificial intelligence by teachers is the personal assistant of a modern teacher developed by the team of the world project "Na Urok" with a selection of AI-based services and examples of their use by teachers to solve various educational tasks (https://naurok.com.ua/ assistant).

The experience of Ukrainian teachers, such as Irina Sokol and Margarita Kalyuzhna, who were among the first to introduce AI to students, shows that today there is a wide range of AI-based services that can be used in education. For example, clear instructions help students learn to use ChatGPT for essay writing. Margarita Kalyuzhna suggests the following steps for students: start with a clear topic, provide additional details, ask specific questions, use keywords, and check grammar and spelling. Other possible tasks could include creating a plan, designing a logo, creating a movie poster, designing an interface, or providing a list of references in a specific format.

Students are particularly interested in AI services that work with images. When working with such services (Universe, Midjourney, Adobe Firefly, Night Cafe Creator, Leonardo AI,

DALL-E, and others), students can explore how the formulation of a request (prompt) affects the generated image.

Possible tasks for students could be designing a logo, a movie poster, an interface, or creating illustrations. It is interesting to compare whether the same image will be generated if the request is written in different languages, such as Ukrainian or English. It is also worth discussing whether AI can replace artists in digital art.

These interactive tasks help students develop skills in using AI effectively and safely.

We developed the course "Introduction to studying the basics of AI". This course is designed for students who are future teachers and current practicing educators. Its objective is to foster teachers' awareness of AI terminology and its underlying principles, promote effective, conscious, and responsible use of AI platforms, and facilitate the acquisition of skills for working with the resources and tools provided by these platforms.

The course consists of two modules: "Fundamental Concepts of AI Development" and "Content Creation using AI". The topics covered in the course are outlined in the following table (Table 1).

Table 1
Curriculum of course.

Module Title	Thema	Activities
The core concepts of artificial intelligence technologies	History of Artificial Intelligence Program Development; Machine Learning and Artificial Intelligence; Data Analytics: Dataset, Regression, Classification, Clustering, Anomaly Detection; Generative Networks; Neural Network Training; Ethics and Legality in AI Program Usage	Exercises in groups on the following topics: Tasks Suitable for AI Delegation; Copyright Issues; Social Impact of AI; Data Collection – Rules and Regulations; Data Research and Classification, Boundary Conditions; Building a Neural Network; Application of Machine Learning Programs – Examples
Creating Content Using Artificial Intelligence Platforms	Machine Learning and Natural Language Processing Using ChatGPT; Aspects of Query Construction; Computer Vision and Fundamentals of Image Recognition; Sound Generation; Generative Networks for Video Processing;	Introduction to AI-based Program Operation; Prompt Writing; Reproducibility of Results; Tasks Addressed by Generative Applications (Business, Education, Management); Generating Unique Outcomes; Critical Evaluation of AI's Performance; Identifying Challenges in Content Creation, Counterexamples

The activity of the first module is gamified. Non-computer tasks can be used for classification, probability assessment, and analyzing parts of images from the neural network's perspective, addressing issues like bias in algorithms, transparency in decision-making, and ensuring that AI serves the greater good. The central theme of this module is statistics, encompassing concepts like regression, coefficient of uncertainty, various forms of variance analysis. An alternative activity could involve discussions or creating startup concepts utilizing AI, or project-based

activities supporting the global goals of sustainable development (Transforming our world: the 2030 Agenda for Sustainable Development).

The second module involves empirical activities. Future teachers not only learn to generate results but also analyze the obtained outcomes. Significantly, attention is drawn to the core dataset handling stages – data classification, boundary conditions, anomaly detection, and correction. Analysis of results is conducted based on these stages. The cyclic nature of this module is due to the similarity in algorithm usage with generative AI programs. The activities within each topic are structured according to the specified algorithm.

4. What a future teacher should know to teach children the basics of artificial intelligence

The formulation of tasks and educational materials for students' work with AI models should adhere to the principles outlined in the Recommendation of the Council on Artificial Intelligence, consider them further.

Inclusive growth, sustainable development, and well-being – formulated tasks should address socially significant problems and contribute to achieving the Sustainable Development Goals.

Human-centered values and fairness – predictions, recommendations, or decisions of AI models in the formulated tasks should be evaluated for their support of vulnerable populations, reducing gender and economic inequality, and addressing social needs.

Transparency and explainability – the formulated tasks should promote a general understanding of how AI models work, critical interpretation of results, and the ability to improve AI models, predictions, recommendations, or decisions based on a clear understanding of their functioning mechanisms. Additionally, considering self-security and the protection of rights, for example, creating a model for personnel hiring assistance that may lead to selectivity based on gender or racial indicators.

Robustness, security, and safety – the constructed models should be analyzed to determine their safety for humans throughout their entire life cycle. Models created should be tested and analyzed for data confidentiality, digital security, and biases related to socially significant issues.

Accountability – the development of AI models, even for educational purposes, should consider the establishment of rules that define the responsibility of participants for the proper functioning of the system. These rules can include guidelines for AI communication, system maintenance, data handling, and security.

The fundamental disciplines for studying the functioning of artificial intelligence models include:

- Basics of linear algebra.
- Basics of mathematical statistics.
- Basics of programming for data analysis.
- Introduction to Machine Learning.

To delve deeper into the study and creation of artificial intelligence models, it is necessary to have a solid foundation in these disciplines. In most cases, understanding the basic principles of artificial intelligence models is sufficient. Some of the essential terms include:

- Artificial Intelligence System.
- Machine Learning.
- Natural Language Processing.
- Computer Vision.
- Neural Networks.
- Deep Learning.
- Big Data.
- Data Sets/Corpora.
- Artificial Intelligence System Life Cycle.

In many cases, students tend to use the terms "machine learning" and "artificial intelligence" interchangeably. However, the modern approach distinguishes between these two concepts. Machine learning involves making predictions and providing recommendations, while artificial intelligence makes decisions and takes actions based on those predictions and recommendations. Therefore, the concept of "artificial intelligence" is broader and encompasses other related concepts (figure 3).
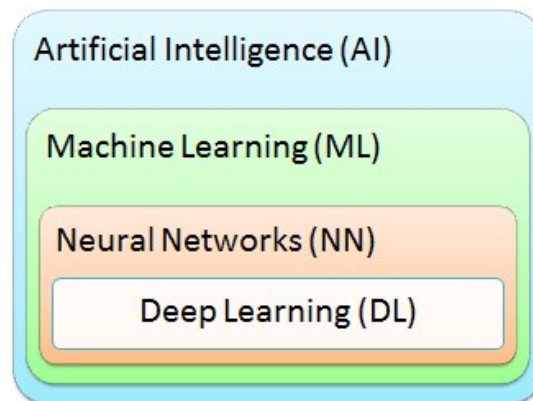

Figure 3: Terms and analogies.

Artificial intelligence platforms utilize machine learning algorithms, and for that, they rely on large datasets known as Big Data. Therefore, both software products and microservices that utilize artificial intelligence will make use of these databases. It is important to understand the following:

- The more training data, the better: Predictions and the scope of application of AI models will be limited when working with small datasets. It is crucial to have a substantial amount of diverse data for effective model building.
- Data has previous creators: Data has authors, and it may be subject to copyright or privacy rights. An example of this is the case of Clearview AI, a company that uploaded and aggregated images of social media users.

- The nature of the data affects the results: Depending on the characteristics of the data, corresponding outcomes can be expected. Therefore, when introducing students to AI models and formulating tasks, attention should be paid to data labeling, providing keywords that describe the data and information about the content of images. The data annotation will determine how AI "perceives" your queries, and the generated results will be based on the set of keywords.
- Data balance: Representativeness of certain concepts is important. The platform may not be aware of certain terms, names, or characteristics specific to a race, gender, culture, or nationality. For example, when querying "Kotigoroshko" or "Ivasyk Telesyk", the results may not resemble familiar images or text.
- Model orientation towards specific tasks: A text generation platform will not generate images, and a general-purpose platform may not provide expert answers to legal queries. A platform built on contemporary texts may not generate text in the style of a different era.
- Data control and censorship: The topic of AI ethics is relevant. Negative experiences from previous developments have led to limitations in generating texts and images. AI platforms will avoid generating content related to topics such as war, violence, disputes, hate speech, and more.

As an example, let's consider one of the tasks using the artificial intelligence builder called Teachable Machine by Google (https://teachablemachine.withgoogle.com/). This builder can be used in practical sessions for creating your own neural network for image, sound, or motion recognition (figure 4).
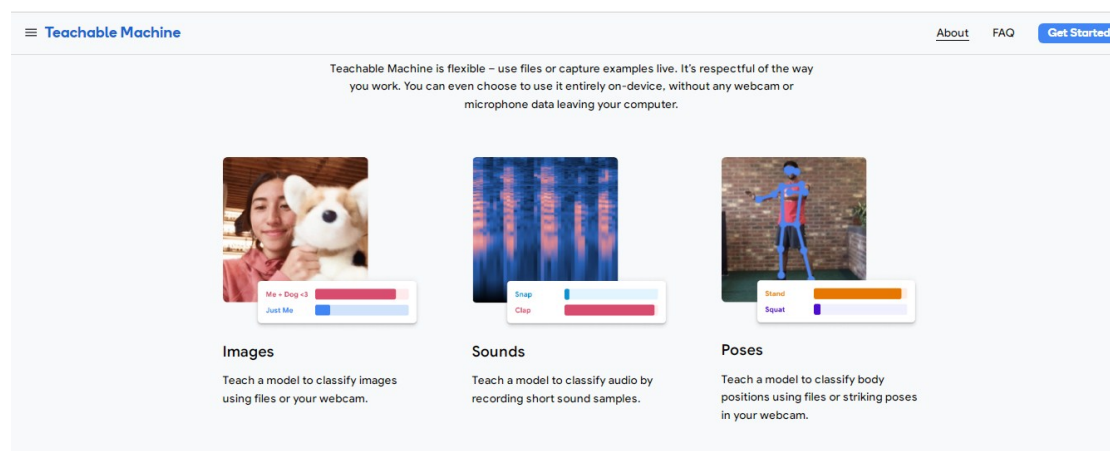

Figure 4: Teachable Machine start page.

The process of building the network consists of three stages:

- Gathering Data: This involves classifying data into different categories. For example, if we want to recognize different parts of a plant, we can use three categories: leaf, stem, and flower. We then populate these categories with data samples.

- Training: This process is performed using Google's algorithms, and the user's task is to select specific training parameters.
- Recognition: This step involves using the trained network. New data that was not included in the classified data sets is inputted, and the network determines the category to which the input belongs.

The following images show the results of a network trained to recognize leaves, stems, and flowers. In the first image, the network identifies the image as a flower with high probability. However, there is also a considerable probability that it is a leaf. If we examine the data set labeled as "leaf", we will find similar images in terms of type and color palette. Therefore, the recognition result as a "leaf" is quite high (figure 5).
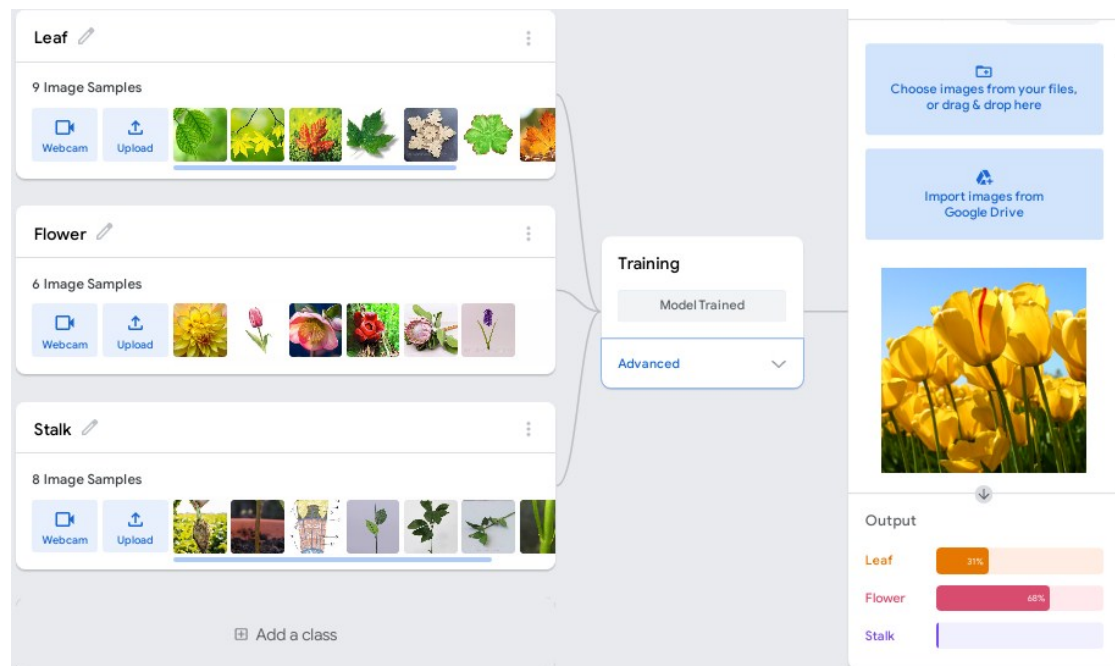

Figure 5: An example of recognising an image that belongs to one of the categories.

In the next image, an input image is provided that cannot be classified into any of the given categories: leaf, stem, or flower. However, the network is unaware of this. It has only been trained on a sample from the provided categories. Therefore, it looks for the closest match to the image. A similar image is found in the "stem" category (color palette, elongated objects). As a result, the network recognizes the image as a stem with high probability. There are also objects within the "flower" category that have similar features, so the network partially recognizes the object as a flower as well (figure 6).

These examples illustrate the importance of the mentioned characteristics: data balance, data cleanliness, data labeling, and data orientation towards a specific task (data completeness).

Currently, there is no such thing as "strong" artificial intelligence capable of performing all intellectual tasks like a human. Instead, we have various artificial neural networks designed for
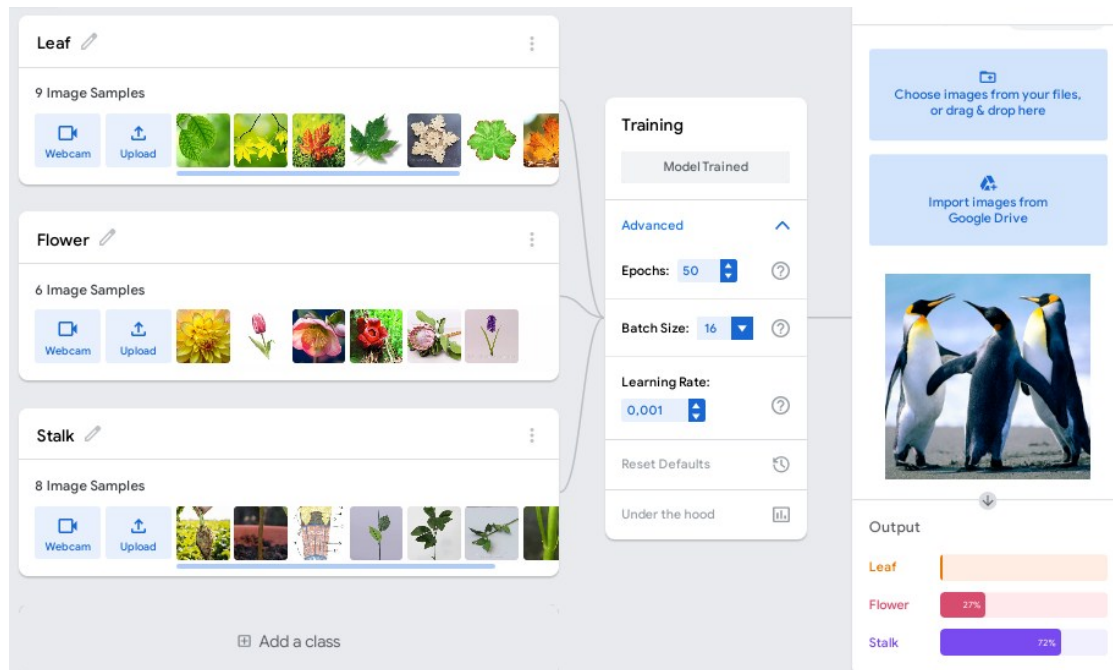
Figure 6: An example of image recognition that does not belong to any of the categories.

specific narrow applications, known as "weak" artificial intelligence.

Therefore, an educational course for future teachers should cover the following topics (figure 7):

- Fundamental concepts and principles of AI.
- Stages of AI learning.
- Ethical considerations in the use of AI, including the possibility of errors.
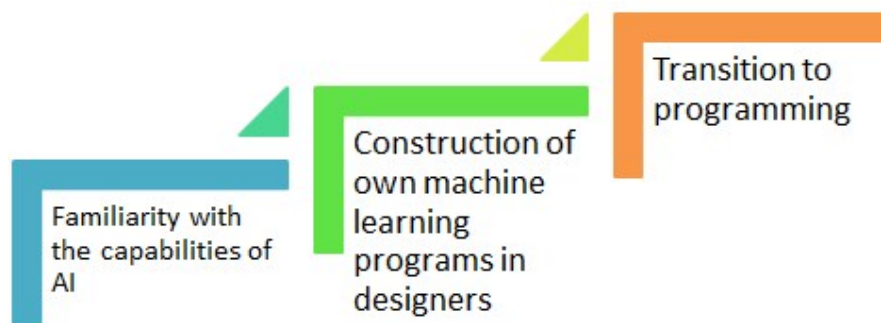

Figure 7: Stages of AI learning.

Graphic AI platforms can perform various tasks:

- Image stylization: The AI takes a user's input image and stylizes it according to a given template, such as the styles of Malevich or Picasso.
- Image generation: Creating an image based on a user's textual description or prompt.

Several meetings of the debate club on AI development have been held at Kherson State University, along with an open lecture by Professor Natalia Valko on the fundamentals of artificial intelligence. Over the past five years, students from the Faculty of Computer Science, Physics, and Mathematics (future programmers and computer science teachers) have been offered topics for their coursework and qualification works related to various aspects of AI development and utilization. The results of a survey conducted in 2023 among computer science education students showed their desire for a more in-depth study of AI's principles and specific applications. As a result, changes were made to the educational program, introducing a course on "Fundamentals of Artificial Intelligence" as an elective component.

5. Recommendations regarding the integration of AI into the educational process of future teachers

Make changes to the regulatory documents of the institution of higher education that regulate the procedures for ensuring the quality of education and include educational components that acquaint students with issues of academic integrity.

Develop recommendations for the use of AI in educational activities, providing explanations of situations where and how AI can contribute to the achievement of learning outcomes. Expand the curriculum of professional training courses by including relevant topics and tasks, for example, disciplines related to the teaching methodology of certain subjects or the use of information technologies in education.

To promote the professional development of university teachers regarding the possibilities of using AI in the educational process. This includes familiarization with methods and tools for identifying the use of AI in student work.

6. Conclusions

The use of artificial intelligence has become an integral part of almost every aspect of our society. While the debate continues about the benefits and dangers of artificial intelligence, the younger generation is increasingly starting to use AI-based services without fully realizing the important aspects. We cannot prohibit the development of science and progress, but we can educate young people to be responsible for the use of any new technologies. Teachers play a crucial role in building the necessary competencies in young people, as they understand the advantages and disadvantages of new technologies, in particular artificial intelligence.

Not all teachers have sufficient preparation for teaching AI. Artificial intelligence courses exist as either supplementary or as separate topics within the school's computer science curriculum. Therefore, it is essential to create a course tailored to the needs of teachers and grounded in a practical approach to acquiring AI skills.

In this research, we have reviewed existing AI teaching courses for teachers, selected technologies and resources, and developed a teacher training program on the fundamentals of AI. One of the advantages of such a program is its practical component and coverage of topics related to the principles of neural networks and artificial intelligence as a whole. The structure of the tasks is designed to allow for remote teaching, which is advantageous in pandemic or wartime conditions.

Based on the research conducted and the experience gained from conducting seminars and sessions using this program, recommendations have been made for the integration of AI into the education of future teachers. In the future, there are plans to research the effectiveness of implementing such a program.

References

[1] S. Lynch, State of AI in 10 Charts, 2021. URL: https://hai.stanford.edu/news/state-ai-10-charts.

[2] R. Kimmons, J. M. Rosenberg, Trends and topics in educational technology, 2022 edition, TechTrends 66 (2022) 134–140. doi:10.1007/s11528-022-00713-0.

[3] Lösungen für eine vernetzte und klimaneutrale Industrie, 2023. URL: https://web.archive.org/web/20230606015237/https://www.hannovermesse.de/de/hannover-messe-2023/.

[4] F. Miao, W. Holmes, R. Huang, H. Zhang, et al., AI and education: A guidance for policymakers, UNESCO Publishing, 2021. doi:10.54675/PCSP7350.

[5] C. Adams, P. Pente, G. Lemermeyer, G. Rockwell, Ethical principles for artificial intelligence in K-12 education, Computers and Education: Artificial Intelligence 4 (2023) 100131. URL: https://www.sciencedirect.com/science/article/pii/S2666920X23000103. doi:10.1016/j.caeai.2023.100131.

[6] Concept of artificial intelligence development in Ukraine. Order of the Cabinet of Ministers of Ukraine of 2 December 2020 No. 1556-p, 2020. URL: https://zakon.rada.gov.ua/laws/show/1556-2020-%D1%80#Text.

[7] H. Gimpel, K. Hall, S. Decker, T. Eymann, L. Lämmermann, A. Mädche, M. Röglinger, C. Ruiner, M. Schoch, M. Schoop, et al., Unlocking the power of generative AI models and systems such as GPT-4 and ChatGPT for higher education: A guide for students and lecturers, Technical Report, Hohenheim Discussion Papers in Business, Economics and Social Sciences, 2023. URL: https://www.econstor.eu/handle/10419/270970.

[8] E. Sabzalieva, A. Valentini, ChatGPT and artificial intelligence in higher education: quick start guide, 2023. URL: https://www.iesalc.unesco.org/wp-content/uploads/2023/04/ChatGPT-and-Artificial-Intelligence-in-higher-education-Quick-Start-guide_EN_FINAL.pdf.

[9] Abitur in Hamburg: Künstliche Intelligenz zum Schummeln genutzt, 2023. URL: https://www.ndr.de/nachrichten/hamburg/Abitur-in-Hamburg-Kuenstliche-Intelligenz-zum-Schummeln-genutzt,abitur540.html.

[10] T. K. Chiu, C.-s. Chai, Sustainable Curriculum Planning for Artificial Intelligence Education: A Self-Determination Theory Perspective, Sustainability 12 (2020). URL: https://www.mdpi.com/2071-1050/12/14/5568. doi:10.3390/su12145568.

[11] J. Song, J. Yu, L. Yan, L. Zhang, B. Liu, Y. Zhang, Y. Lu, Develop AI Teaching and Learning Resources for Compulsory Education in China, volume 37, 2023, pp. 16033–16039. URL: https://ojs.aaai.org/index.php/AAAI/article/view/26904. doi:10.1609/aaai.v37i13.26904.

[12] R. Williams, S. Ali, N. Devasia, D. Dipaola, J. Hong, S. Kaputsos, B. Jordan, C. Breazeal, AI + Ethics Curricula for Middle School Youth: Lessons Learned from Three Project-Based Curricula, International Journal of Artificial Intelligence in Education 33 (2023) 325–383. doi:10.1007/s40593-022-00298-y.

[13] A. Przegalinska, D. Jemielniak, Strategizing AI in Business and Education: Emerging Technologies and Business Strategy, Elements in Business Strategy, Cambridge University Press, 2023. doi:10.1017/9781009243520.

[14] N. V. Valko, T. L. Goncharenko, N. O. Kushnir, V. V. Osadchyi, Cloud technologies for basics of artificial intelligence study in school, in: A. E. Kiv, S. O. Semerikov, M. P. Shyshkina (Eds.), Proceedings of the 9th Workshop on Cloud Technologies in Education, CTE 2021, Kryvyi Rih, Ukraine, December 17, 2021, volume 3085 of *CEUR Workshop Proceedings*, CEUR-WS.org, 2021, pp. 170–183. URL: https://ceur-ws.org/Vol-3085/paper31.pdf. doi:10.55056/cte.113.

[15] Artificial Intelligence for Schoolchildren Course, 2021. URL: https://osvita.diia.gov.ua/courses/artificial-intelligence.

[16] Prometheus, Machine Learning, 2022. URL: https://prometheus.org.ua/course/course-v1:IRF+ML101+2016_T3.

[17] Google, AI Fundamentals course, 2022. URL: https://rsvp.withgoogle.com/events/ai-basics_2023?fbclid=IwAR28AXzf67WIV1TTHVfuvCmXkKPiH-jdi17krVPaL3gQmtIvzqM3hhTV5Hk.

[18] O. Pasichnyk, O. Molchanovskyi, V. Osaulenko, F. V. Tamayo, The course "Grade 10-11. Computer Science. Artificial Intelligence", 2021. URL: https://ukraine.learningpassport.unicef.org/#/course/58/item/513.