

SECTION 2. Digitalization of the Educational Space: From Distance Learning Platforms to Metaverses

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SECTION 2.

DIGITALIZATION OF THE EDUCATIONAL SPACE: FROM DISTANCE LEARNING PLATFORMS TO METAVERSES

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METHODOLOGICAL APPROACHES TO THE USE OF GOOGLE COLABORATORY IN THE PRACTICAL TRAINING OF STUDENTS

Abstract: *The article summarizes the practical experience of using Google Colaboratory in the educational process at different educational levels. The technical advantages of the environment are evident: no installation required,*

access to computing resources, native integration with Google Classroom and Google Drive, and support for teamwork. The author proposes a methodological model for organizing practical work in the Colab environment, demonstrating the structure's versatility across various subject areas, from the basics of programming in secondary education institutions to data analysis and artificial intelligence systems in higher education institutions. The limitations of the free platform tariff are identified, and methods to compensate for them are proposed.

Keywords: Google Colaboratory, cloud learning technologies, digitalization of education, education levels, programming, data analysis, methodological model.

Introduction. The Python programming language is increasingly used in the educational process not only as a tool for training specialists in information technology, but also as a means of developing computational thinking, data analysis skills, and automating routine tasks across various subject areas. This is especially relevant in preparing IT profile students when studying data analysis methods or working with neural networks, and is consistent with the global trend of rapid growth in research on artificial intelligence applications in education [1].

Researchers currently consider cloud technologies to be a promising area for the development of modern education, providing free access to educational resources and computing power without being tied to a specific workplace [2]. At the same time, participants in the educational process face several systemic difficulties: the heterogeneity of technical equipment across educational institutions, the complexity of configuring the local software environment on educational laboratory computers, and the need to provide a common workspace for performing and checking practical and laboratory work. This problem is not only domestic but also international in nature: foreign researchers identify the complexity of setting up the programming environment as one of the main barriers for beginners studying data analysis and offer cloud solutions to overcome it [3]. The spread of distance and blended learning, particularly in IT training for students at higher education institutions, has further underscored the need for tools that do not require installation and are equally accessible on any device[4].

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Under such conditions, an effective solution is to use cloud-based interactive development environments, among which the leading place is occupied by the Google Colaboratory (Colab) platform – a free cloud environment based on Jupyter Notebook, which provides access to computing resources without the need for additional settings and supports joint work on one document in real time [5]. We have already considered the use of cloud services to support teamwork in the process of learning programming [6]; however, the practical experience of using Google Colab in teaching disciplines across different levels of education requires a separate, systematic generalization.

Article Purpose: to summarize methodological approaches to using Google Colaboratory in the educational process at different levels of education, to identify the didactic capabilities of the platform for organizing practical training, and to present the experience of its use in teaching programming, data analysis, and artificial intelligence systems.

Results: Google Colab is an interactive notebook in which code, explanatory text, formulas, and execution results (graphs, tables, and output) are all contained in a single document. This significantly reduces the cognitive load on beginners by eliminating the need to switch between the editor, terminal, and browser. The environment supports the full standard stack of Python libraries for working with data, available without prior installation: NumPy, Pandas, Matplotlib, Seaborn, Scikit-learn, etc. For disciplines related to machine learning and neural network development, the platform provides access to the TensorFlow and Keras libraries, allowing students to move directly from theoretical material to practical model implementation without spending time setting up the environment.

Integration with Google Drive enables automatic saving of notebooks and downloading of datasets, and the link-sharing feature fully replicates the teamwork model familiar to students from Google Docs. Access to GPUs on the free plan significantly speeds up neural network training, which is especially important for computer classes in educational institutions that often lack specialized equipment for such tasks.

Among alternative cloud environments, it is worth mentioning Kaggle Notebooks, which are primarily focused on data analysis competitions and are less convenient for integration with learning management systems. Another option is deploying Jupyter Notebook on a personal server, which requires

administration and technical support – a task complicated by the heterogeneous technical equipment of educational institutions. Compared to them, Google Colab combines zero configuration, native integration with Google Classroom and Google Drive, and free access to computing resources, which led to the choice of this platform for organizing the educational process described in this article. Based on the analysis of scientific sources and the generalization of one's own pedagogical experience, a methodological model of using Google Colaboratory in the practical training of education seekers is proposed (Fig. 1). The model reflects the sequence of organizing educational activities: from determining the content of the educational component and setting a practical task to organizing work in a cloud environment, performing individual, team, and independent work, analyzing the results obtained, and forming professional competencies. A feature of the model is its versatility, which enables its use in both secondary education institutions for teaching the basics of programming and higher education institutions for studying disciplines related to programming, data analysis, and artificial intelligence systems.

The key difference lies not in the model's structure but in the subject content of each stage, which varies by level of education. In secondary education institutions, the model is implemented through programming and algorithmization materials; practical tasks focus on mastering the basic structures of the Python language. In higher education institutions, the model itself is scaled to more complex subject content - data analysis, building and training neural networks – while maintaining the same sequence of organizing educational work. Such universality of the model, further demonstrated with specific examples, indicates the didactic flexibility of the Google Colaboratory platform as a tool not tied to a specific level of complexity in the educational content. In the school course, Google Colab is advisable for specific practical tasks when studying the basics of Python programming. For example, after a brief explanation of the topic, students can immediately perform exercises: calculate the values of expressions using formulas, create programs for working with strings (search for symbols, count words), and build simple graphs of functions or dependencies. The «seen – done – changed» principle is effective: the teacher demonstrates a code example, after which students copy a file containing examples and theory and modify it (change data, conditions, parameters), allowing them to see the result immediately.

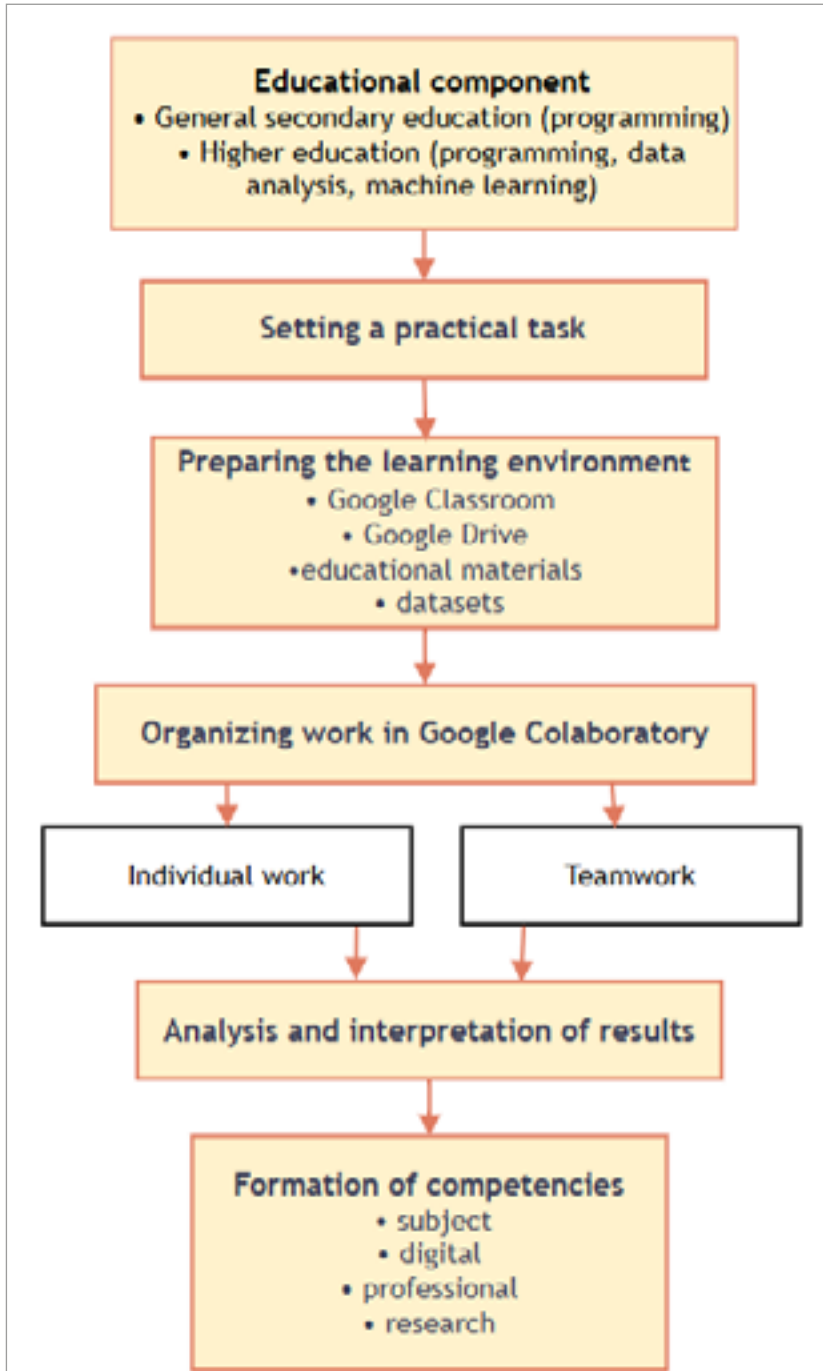


Fig. 1. Methodological model of using Google Colaboratory in practical training of education seekers

It is also advisable to use mini-tasks of a research nature: build a temperature graph for a week, analyze a simple data table, or consider the features of outputting structured data, etc. Because the environment does not require installation, students can continue working at home by opening the same notebook via the link, which contributes to the development of independence and the consolidation of practical programming skills. For high school students, team-based project implementation can be organized with joint editing of a single notebook.

Another significant advantage is the native integration of Google Colab with Google Classroom [7]. This enables a link to the notebook to be placed as an assignment directly in Classroom, after which students can complete the work in their own copy of the file, which is automatically saved on their Google Drive. This simplifies the collection and verification of work, enables comments (remarks or additional explanations) to be left directly in the document near the corresponding lines of code or sections of text, and provides convenient execution control within a single educational environment (Fig. 2).



Fig. 2. Using comments to explain the result of the task

In higher education institutions, the Google Collaboratory service is advisable for teaching IT disciplines, the practical component of which involves programming in Python, data analysis, and building machine learning models. Practical tasks can cover the full cycle of working with data: loading, preprocessing, statistical analysis, visualization, classification, clustering, forecasting, and the implementation of basic

artificial intelligence models. A typical educational notebook contains theoretical material, a demonstration example with explanations, and tasks for independent execution in their own copy of the document. Such a structure simplifies the organization of laboratory classes, provides the teacher with prompt access to students' work results, and creates a single environment for performing practical tasks. During work, students use the Pandas, NumPy, Matplotlib, Seaborn, Scikit-learn libraries, and if necessary, TensorFlow and Keras to build and train neural networks. Using a GPU in the free tariff makes it possible to demonstrate machine learning examples without specialized equipment.

The practice of using Google Colaboratory confirms its effectiveness when studying various IT disciplines related to data analysis, machine learning, and artificial intelligence systems. This indicates the platform's versatility and its potential to serve as a single cloud environment for organizing practical training for students.

An important advantage of the platform is the support for teamwork. Student groups can jointly edit a single document, simulating real-world team development and data analysis. The teacher sees changes in real time, can leave comments directly in the cells, and track the progress of each group member. This format has proven itself well during the implementation of educational projects: students distribute the stages of data processing among themselves (for example, one processes data cleaning and preparation, another – statistical analysis, the third – visualization and interpretation of results) and work in parallel in one environment, which brings the educational process closer to the conditions of real team development of software products.

In addition to purely technical convenience, this format of work also has a methodological effect: it allows the teacher to evaluate not only the final result, but also the process – the sequence of actions, the distribution of the workload between group members, and the timeliness of the corrections made, which is important when assessing the individual contribution of each student to the group task.

Along with the advantages, the platform has limitations that should be taken into account when organizing the educational process. In particular, the amount of RAM in the free plan is limited, which imposes restrictions on working with large data sets - during laboratory work, this is manifested

primarily when students try to use too bulky datasets or run several resource-intensive calculations simultaneously. Dependence on a stable Internet connection is also a significant factor, especially when working in a computer classroom with limited network bandwidth or when performing tasks at home under uneven coverage across regions.

These limitations, however, do not negate the advantages of the platform for educational purposes and can be compensated for by appropriate methodological design of tasks: selection of training datasets of optimal size (sufficient to illustrate the method, but without excessive load on resources), early warning of students about the advisability of saving intermediate results, as well as providing a backup option for completing the task (for example, a reduced data sample) in case of technical difficulties with network access. This approach preserves the didactic value of practical tasks even under free-tier plan limitations. Unlike most published works, which consider Google Colaboratory mainly as a software tool or cloud development environment, the article proposes a methodological model for its use, suitable for the practical training of students at different levels of education.

Conclusions: The analysis of practical experience using Google Colaboratory across different levels of education confirms the platform's didactic effectiveness as a tool for organizing educational activities in programming, data analysis, and artificial intelligence systems. The key advantage of the environment is the absence of installation and configuration, which removes the barrier posed by heterogeneous technical equipment across educational institutions, and native integration with Google Classroom and Google Drive provides a convenient cycle of setting, performing, and checking practical tasks.

The methodological approach to organizing work in the Google Colab environment proposed in the article demonstrates its versatility: while maintaining an unchanged structure (from setting a practical task to analyzing results and forming competencies), it is scalable to different subject content – from basic programming structures in secondary schools to data analysis, building, and training neural networks in higher education institutions. This allows us to consider the model suitable for replication across different disciplines of the computer cycle, rather than merely as a description of a single practical experience.

Based on the above, practical recommendations for teachers can be formulated: design educational notebooks according to a single structure (theoretical block – demonstration example – tasks for independent performance); consciously choose the volume of training datasets taking into account the limitations of the free platform tariff; use the joint editing functionality to organize teamwork and evaluate not only the result, but also the process of completing the task. Prospects for further research include experimental verification of the proposed methodological model's effectiveness, its adaptation to other IT disciplines, and integration with generative artificial intelligence systems.

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