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INTEGRATING ARTIFICIAL INTELLIGENCE INTO THE STUDY OF SCHOOL INFORMATICS

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Abstract. The article explores the integration of Artificial Intelligence (AI) into school informatics education, focusing on the context of the Republic of Moldova. The first part provides a comparative analysis of how AI is introduced into the Informatics/ICT curricula of Romania, the Republic of Moldova, Germany, and Finland for the 2025-2026 period. The second part proposes a practical and accessible AI integration model, termed a "low-resource hybrid" model, adapted to Moldovan realities. This model relies exclusively on free and open-source tools—such as Teachable Machine, Google Colab, Scikit-learn, Scratch, and local Ollama—and is structured around three pillars: conceptual foundations, practical implementation, and an adapted curriculum. Furthermore, the article presents a realistic implementation strategy involving "Clasa Viitorului" hubs, Tekwill partnerships, and open government data, alongside a detailed lesson plan for the 9th grade and an interactive worksheet. The emphasis is placed on ethical aspects, prompt engineering, and narrowing the urban-rural digital divide.
Keywords: Artificial Intelligence, school informatics, digital curriculum, AI integration.

INTEGRAREA INTELIGENȚEI ARTIFICIALE ÎN STUDIEREA INFORMATICII ȘCOLARE

Rezumat. Articolul explorează integrarea Inteligenței Artificiale (IA) în predarea informaticii școlare, cu accent pe contextul Republicii Moldova. Prima parte realizează o analiză comparativă a modului în care IA este introdusă în programele de informatică/TIC din România, Republica Moldova, Germania și Finlanda (situația 2025-2026). Partea a doua propune un model practic și accesibil de integrare a IA (denumit hibrid low-resource), adaptat realităților moldovenești. Modelul se bazează exclusiv pe tool-uri gratuite și open-source (Teachable Machine, Google Colab, Scikit-learn, Scratch, Ollama etc.) și este structurat pe trei piloni: fundamente conceptuale, implementare practică și curriculum adaptat. Sunt prezentate o strategie de implementare realistă (hub-uri „Clasa Viitorului”, parteneriate Tekwill, date guvernamentale deschise), un plan de lecție detaliat pentru clasa a IX-a și o fișă de lucru interactivă. Accentul cade pe aspectele etice, prompt engineering și reducerea decalajului digital urban-rural.
Cuvinte cheie: Inteligență Artificială, informatică școlară, curriculum digital, integrare IA.

Comparative Analysis: Integrating Artificial Intelligence (AI) into Computer Science Curricula in Romania, the Republic of Moldova, Germany, and Finland (2025–2026 Status)

The integration of Artificial Intelligence into school education represents a strategic priority at the European level, and the way it is reflected in computer science curricula differs significantly between Eastern and Western European countries. A comparative analysis of the 2025–2026 landscape in Romania, the Republic of Moldova, Germany, and

Finland reveal both notable progress and persistent gaps regarding the level of curricular integration, instructional content, pedagogical approach, and teacher support.

Based on recent official documents (approved school curricula, national standards, and European reports), this study evaluated how AI is introduced into the computer science/ICT curriculum at the secondary level (lower and upper high school). The comparative analysis examines the level of integration, content, pedagogical approach, teacher training, and resources, identifying both best practices and gaps. The data is sourced from the official curricula of the Ministry of Education (MEC) in Romania (2025), the Framework Plan of the Ministry of Education and Research (MEC) in Moldova (2025–2026), the standards of the German Informatics Society (GI, 2025), and the guidelines of the Finnish National Agency for Education (OPH, 2025), alongside the national project 'Generation AI'. Accordingly, Table 1 illustrates the level of AI integration within the curriculum.

Table 1. Level of AI integration within the curriculum

Country	Curriculum status	Primary level	Mandatory?	Notes
Romania	Integrated into ICT (common core) + Informatics (specialization)	High school (Gr. IX+)	Yes (ICT) / Partial (Informatics)	2025 Reform: AI explicit in ICT (1 hr/week)
Moldova	Informatics + ICT (optional/variable component)	Middle school + high school	Partial (1 hr/week)	No explicit AI mention in the central framework; separate initiatives (optional, ONIA, SuperCoders)
Germany	GI 2025 standards for lower secondary informatics; integrated cross-curriculum	Lower secondary (Gr. 5–10)	Being made mandatory (e.g., Hamburg from 2025)	Varies by state; integrative approach
Finland	Cross-curricular + national AI guidelines 2025; no separate informatics curriculum	All levels (K-12)	Not separate, but integrated	National strategic project Generation AI

At the curricular level, Western European countries demonstrate greater maturity. In Finland, AI does not constitute a separate subject, but is integrated cross-curricular across all K-12 levels through the national guidelines of the Finnish National Agency for Education [1, 2] and the strategic project Generation AI [3]. Germany adopted in 2025 the revised standards of the German Informatics Society (GI), which extend existing computational thinking with AI-specific perspectives, with integration already mandatory or in the process of becoming mandatory in several states [4, 5]. By contrast, Romania carried out a rapid reform in 2025 by explicitly including AI in the mandatory Information and Communication Technology (ICT) curriculum for Grade IX common core, while the Informatics specialization curriculum addresses elements of machine learning [6, 7]. The Republic of Moldova remains at the most nascent stage: the 2025–2026 Framework Plan

mentions general digital competencies but does not contain a mandatory AI module in informatics; the subject appears only optionally or through extracurricular initiatives [8, 9, 10].

From the perspective of content and pedagogical approach, Finland and Germany emphasize a holistic and ethical perspective: students are trained not only in the use of AI tools, but also in understanding their limitations, biases, and human responsibility. Romania adopts a balanced, practical, and accessible approach—prompt engineering, Teachable Machine, fact-checking, and ethical aspects are integrated directly into ICT lessons. In Moldova, explicit AI content is still limited to pilot projects and Olympiads (ONIA, SuperCoders), which creates a discrepancy between students' theoretical and practical competencies. Teacher training and available resources represent another differentiating factor. Western European countries benefit from extensive national continuing education programs and abundant open-source resources. Romania offers video guides and MEC materials, but training remains insufficient at the national scale. In the Republic of Moldova, the Tekwill and UNICEF STEAM initiatives are strong points, but unequal access to infrastructure (especially in rural areas) and the lack of a coherent national teacher continuing education strategy constitute major gaps. Best practices identified include the cross-curricular integration and emphasis on ethics from Finland, the flexible professional standards from Germany, and the rapid, free-tool-oriented reforms from Romania. The main gaps common to Eastern European countries are still partial/optional integration, the urban-rural digital divide, and insufficient teacher preparation. Germany faces variations between states, while Finland faces the risk of inequalities generated by excessive school autonomy.

In summary, the Finnish and German models offer valuable references for systemic, ethical, and sustainable AI integration, while the Romanian experience demonstrates that curricular reforms are possible even in resource-constrained contexts. For the Republic of Moldova, accelerating the adoption of a mandatory AI module in ICT/Informatics, combined with scalable training and a low-resource framework (based on free tools such as Scratch, Teachable Machine, and local Ollama), would represent an essential step toward closing the digital divide and aligning with European 21st-century competency standards. This comparative analysis underlines the need for an approach adapted to the local context, but inspired by the best European practices.

A Model for Integrating Artificial Intelligence into School Informatics Education in the Republic of Moldova

Introducing Artificial Intelligence into schools does not need to be a costly or ultra-technical process. For the context of the Republic of Moldova, where resources can vary between urban and rural areas, the most effective model is a hybrid one that emphasizes

understanding concepts through free tools and applying them in languages already being studied.

Below, we present a proposed model structured around three pillars:

1. *Foundations and democratizing access*

Before writing code, students must understand what AI is. Instead of expensive servers, we use browser-based platforms that run on any computer with an internet connection. Such platforms include:

- Machine Learning for Kids: A free platform that allows the training of simple models (text, images, numbers) and their integration into Scratch or Python. Ideal for middle school.
- Google Teachable Machine: An extremely fast visual tool for explaining image and gesture classification without writing a single line of code.

2. *Open-source Implementation (for High School Students)*

For high school students who already study Python, the transition to AI can be made using standard libraries and development environments that do not require complex installations. The recommended tools here are:

- Google Colab: Provides free access to GPUs (graphics processing units) directly in the browser. Students can run Machine Learning models without needing high-performance computers in the lab.
- Scikit-learn: The "gold standard" library for Python beginners. It is open-source and perfect for learning regression or decision algorithms.
- Hugging Face: The "GitHub" of AI. Students can explore pre-trained language or image processing models to see real-world applications.

3. *Adapted curriculum: "AI as assistant and object of study"*

We propose integrating AI into the informatics curriculum not as a separate subject, but as an applied module. Table 2 includes the structure of these AI integration modules in school informatics education.

Table 2. Structure of the AI integration model

Module	Recommended practical activities	Recommended tools
AI Fundamentals (Beginner, 8–10 hrs, Middle School)	Interactive discussions, simple simulations without code.	***Scratch (open-source, free):*** AI extensions for creating simple games with voice/image recognition. ***Teachable Machine*** (Google, free, partially open-source): Web-based, save able locally; trains simple image/sound classification models without code.
Programming & Practical Applications (Intermediate, 10–15 hrs, Middle / High School)	Hands-on projects such as analyzing school data (grades, absences).	***Orange Data Mining*** (open-source, free): Desktop application for visualization and machine learning without intensive coding. ***Jupyter Notebooks via Anaconda*** (open-source, free): Installed locally; uses libraries such as Scikit-learn for basic ML.

Ethical Aspects & Advanced Projects (Advanced, 8–10 hrs, High School)	Discussions on risks (bias, privacy) and responsible applications.	***Ollama*** (open-source, free): Runs LLM models locally on PC (e.g., small Llama 2). Requirements: PC with minimal GPU (small models work on CPU). ***Hugging Face Datasets*** (open-source, free): Download datasets offline; used with local Python.

Within the teaching of these modules, the emphasis must fall on prompt engineering (how to ask for information correctly) and on the critical verification of AI-generated results, thereby preventing passive plagiarism. For this model not to remain a purely theoretical concept, its implementation in the context of the Republic of Moldova must be pragmatic and make use of existing infrastructure. Moldova has the advantage of a vibrant IT community and projects such as "Clasa Viitorului" (Classroom of the Future) and "Tekwill in Every School", which can serve as a foundation. Below is a detailed implementation strategy:

1. *Using Existing Technology Hubs*

Instead of trying to equip every school from scratch, the strategy is based on a "Hub & Spoke" system:

- "Clasa Viitorului" Centers: These should become regional training hubs. Informatics teachers can participate in "train-the-trainer" workshops where they learn to use Google Colab and open-source tools.
- Digital Laboratories: Using resources from renovated labs to run web-based AI applications that do not require significant local processing power, but only a stable internet connection (in which Moldova performs very well).

2. *Integration with Open Government Data (date.gov.md)*

A major problem in studying AI is the lack of relevant data. Students from the Republic of Moldova can learn AI by solving local problems. Examples of classroom projects would include using datasets about public transport, energy consumption, or meteorological data from Moldova to create simple prediction models. This will show students that informatics is not merely theoretical, but a tool for improving their community.

3. *Partnerships with the private sector (mentorship)*

IT companies in Chișinău and residents of the Moldova Innovation Technology Park (MITP) can play an active role. Here, a program called "Adopt a School" could be initiated, where software engineers can offer online mentorship sessions via Google Meet or Zoom for high school classes, explaining how AI is used in the real industry (e.g., in FinTech or e-Commerce). Additionally, school hackathons can be organized, with annual "AI for Social Good" competitions where the best student project ideas can receive small grants or equipment.

4. *Adapting the Informatics Curriculum*

There is no need to create a new subject—the goal is to infuse existing modules:

- Python Language - In Grade 10/11, the pandas (for data) and scikit-learn (for AI) libraries can be introduced.
- Cybersecurity - Discussing AI risks (AI-generated phishing, deepfakes) within digital security modules.

Resources in Romanian and accessibility

Many top resources (Code.org, Khan Academy) are in English. Language can be a major barrier for students in rural areas. To address this, we propose content localization through the creation of a national portal (under the auspices of MEC) that centralizes short video tutorials and worksheets (such as the one presented below) translated and adapted to the local context. For schools with unstable internet, tools such as Orange Pi or versions of small models that can run locally on older computers can be promoted.

Below we propose a short resource guide (links and free courses) that teachers from the Republic of Moldova can access to get started in the field of AI for education:

1. *Teacher training courses with certificate completion*

These courses provide the theoretical and methodological foundation needed to teach AI.

- The "Clasa Viitorului" Centre in the Republic of Moldova periodically organizes training courses on Artificial Intelligence in Education (8 hours, in-person/hybrid format). Link: mecc.gov.md – AI Training
- Elements of AI in romanian – the world's most popular introductory course, created by the University of Helsinki. It is free, available in Romanian, and explains concepts without heavy mathematics. Link: elementsofai.ro
- Microsoft for Educators – AI Learning Path is a free learning path showing how Microsoft Copilot and other AI tools can be used to streamline lesson preparation. Link: Microsoft AI for Educators

2. *Platforms and curriculum for classroom use*

Ready-to-use tools at the computer, with lesson plans included.

- Tekwill in Every School – a national platform offering the optional course on "Artificial Intelligence". Teachers can access video resources and course materials after registering their institution. Link: tekwill.online
- Google Teachable Machine – the #1 tool for quick classification experiments (images, sounds, poses). No account or installation required. Link: teachablemachine.withgoogle.com
- Code.org – AI for Oceans – a 45-minute interactive (game-style) activity that teaches students about bias and data training, saving the ocean from waste. Link: code.org/oceans

3. *Free productivity tools for teachers*

Tools that can be used to generate teaching materials or explain concepts:

– Gemini (Google) – for generating tests, lesson plans, and explanations. Link: https://gemini.google.com/
– Canva Magic Studio – for generating educational presentations and images. Free for teachers (Canva for Education).
– Google Colab – for running Python code for AI directly in the browser. Link: https://colab.research.google.com/

4. *Communities and local support*

– Facebook Groups – search for "Comunitatea profesorilor Clasa Viitorului" or "Tekwill în fiecare școală" to exchange experiences with other colleagues who are already implementing these modules.
– Webinars – follow the pages of strategic partners (USAID Moldova, Sweden, MEC) for announcements about new grant programs for AI labs.

Sample lesson plan for the first hour of Introduction to AI, adapted for grade 9 students

This lesson plan is designed to demystify Artificial Intelligence, transforming it from an abstract concept into a tangible tool, using free resources and an interactive approach. The Lumio tool can be used for presenting the lesson, where various resources needed for teaching can be created.

Target group: Grade IX

Duration: 45 minutes

General objective: Students will understand the difference between classical programming and Machine Learning through direct experimentation.

I. *Introduction and Ice-Breaking (7 minutes)*

- Discussion: Students will answer the following questions from their computers:
- "How does YouTube/TikTok know what videos to show you next?"
- "How does your phone recognize your face?"
- Brief definition presented: Classical programming uses strict rules (If A, then B). AI learns on its own from examples (Data).

II. *Practical Demonstration: Teachable Machine (15 minutes)*

An image classification model will be trained in real time, without code.

1. Access: Students open Teachable Machine (teachablemachine.withgoogle.com).
2. Data collection:
   - Class 1: The student holds a textbook in front of the webcam.
   - Class 2: The student holds a notebook in front of the webcam.
3. Training: The "Train Model" button is pressed. It is explained that at this moment the computer is searching for patterns in pixels.

4. Testing: The student checks whether the model correctly recognizes when they hold up the object and when they do not.

III. *Algorithms and ethics (10 minutes)*

We use the Quick, Draw! game created by Google to discuss datasets.

1. *Activity*: Student's access https://quickdraw.withgoogle.com/ and draw 6 objects requested by the AI.
2. *Critical question*: "Why did the AI recognize the circle as a wheel and not an apple?" This question will be adapted to the objects requested by the AI. To find out why a drawing was not recognized, we can click on it and get details.
3. *Key concept*: Bias. If we train a model only with pictures of red apples, it will not recognize a green apple. Input data dictates AI behavior.

IV. *AI in Python – First Steps (8 minutes)*

To connect with Moldova's informatics curriculum, we present what the "brain" of an AI looks like in code using Google Colab. An example is shown in Figure 1.

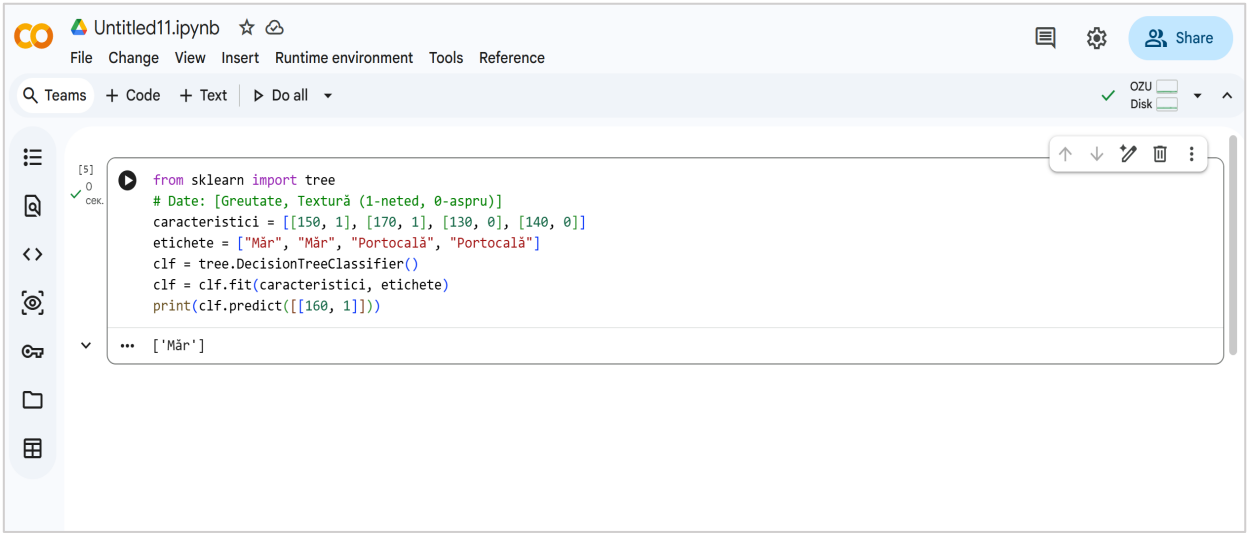

Figure 1. Example of model identification through Python programming

Sample Worksheet for the Practical Teachable Machine Demonstration from the Lesson Plan Above

WORKSHEET: Training my first Artificial Intelligence model

Student name: _____

Date: _____

1. *Collection phase (Input Data)*

In the Teachable Machine experiment, create two categories (classes). Note what you used for each:

- Class 1 (Name): _____ (e.g., "Me")
- Class 2 (Name): _____ (e.g., "Notebook")
- Number of samples (images) collected: _____ per class.

2. *Training phase (Processing)*

What happened when you pressed the "Train Model" button?

- The computer memorized the images exactly as they are.
- The computer searched for patterns (shapes, colors, edges) to differentiate the classes.

3. *Testing phase (Results)*

Put the model to the test! What happens if:

- You bring the object very close to the camera?

_____

- You change the lighting or move quickly?

_____

- You show a new object that the AI has not seen during training?

_____

4. *Critical reflection*

If you wanted this model to work perfectly for all of your classmates, what would you need to change about the "input data"?

_____

_____

This worksheet can be created on Google Keep, to which students can have access via a link, or it can be printed and distributed to students during the informatics class.

Conclusions

The integration of Artificial Intelligence in schools in the Republic of Moldova does not need to be a costly process, but rather one oriented toward the intelligent use of open-source tools and the cultivation of an ethical perspective on technology. The Republic of Moldova is in an early stage, where AI competencies are currently addressed primarily through optional subjects, extracurricular initiatives (such as Tekwill or ONIA), and pilot projects. The current framework plan focuses on general digital competencies, with a gap between theoretical and practical preparation, further exacerbated by unequal access to infrastructure between urban and rural areas. To reduce the digital divide, this article proposes a hybrid and pragmatic model adapted to the local context. Adopting a mandatory AI module, supported by public-private partnerships, represents the essential step for aligning students from the Republic of Moldova with the European standards of the 21st century.

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