AI Courses for Secondary and High School – Comparative Analysis and Conclusions

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Abstract

The paper discusses some ideas underlying the vision for Bulgaria to become a regional centre for education and research in the field of artificial intelligence in the coming years, outlined in several national strategic documents. Special attention is paid to a number of issues related to the creation of appropriate high school curricula, related to artificial intelligence. A comparative analysis of existing artificial intelligence courses suitable for secondary and high school students has been presented and corresponding conclusions and recommendations have been formulated.

Keywords

Artificial intelligence, high school education, search, planning, machine learning, knowledge representation and reasoning

1   Introduction

The rapid penetration of Artificial Intelligence (AI) in a wide set of areas of economy and everyday life, as well as the ongoing and predicted changes in the labour market, require appropriate inclusion of the topic of AI in education at all levels.

The Beijing Consensus on Artificial Intelligence and Education [4] sets out several common guidelines for the process of including various aspects of AI in school and university curricula. The most significant of them emphasize the following principles: "develop strategies for AI in education that are aligned and integrated with education policies, within a lifelong learning perspective"; "take institutional actions to enhance AI literacy across all layers of society"; "develop local AI talent, to create a massive pool of local AI professionals who have the expertise to design, program and develop AI systems"; "be mindful of the importance of adopting principles of ethics-, privacy- and security-by-design"; "support the integration of AI skills into ICT competency frameworks".

Specific measures are suggested in the strategic documents at the European and national level (e.g. [1, 3, 6, 7]), the implementation of which would allow the education system in Bulgaria to meet the challenge to provide the development of knowledge and skills needed for work in the field and AI, as well as for work in an AI environment. Unlike higher education and research, these measures are formulated very generally for the level of secondary and high school education [6, 7]:

- Significant increase in the role of the so-called STEM (Science, Technology, Engineering, and Mathematics) disciplines as well as the disciplines related to the acquisition of digital competencies in school education.
- Acquisition of digital skills specific to the creation and application of AI – both analytical (such as data structuring, algorithm design, deductive and inductive reasoning, solving complex problems,

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etc.) and applied (such as programming languages and software environments for building applications with AI).

- Increasing the competencies of students in the field of ethical issues related to the use of information technologies and their rights in the digital world in which they live.
- Focusing school education on the acquisition of four categories of skills and abilities: cross-sectoral cognitive skills (in particular, understanding of natural language texts and numerical data, problem-solving ability, etc.); creative abilities; social and situational skills (teamwork skills, independence, etc.); precise abilities related to perception and handling.

It is expected that in this way the acquisition of key knowledge and skills for professional realization using AI will be achieved. This will also lead [2, 5] to overcome the predicted structural reduction of professionals with vocational education in the medium and long term.

On the other hand, according to the Concept for the Development of AI in Bulgaria until 2030 [7], the introduction of AI in school education programs will have a deep effect on the skills required by 2030. The acquisition of these skills should lead to faster and easier adaptation of students to the work environment after graduation and would prepare them for the professions of the future. The programs for the high-tech vocational high schools should be prepared and constantly adapted with the help of universities and other research organizations, as well as in close cooperation with the leading Bulgarian companies in the field of AI.

The paper presents some results of a study of existing AI courses for students mainly at secondary and high school level, as well as some of the widely available massive open online courses (MOOCs), the content of which can be used directly or adapted for this purpose. Conclusions and recommendations have been made concerning the content of the AI education and training of high school students.

2 School-oriented AI courses

There is a rapidly increasing number of AI courses designed especially for school students, which aim to show young people fascinatingly and convincingly "what artificial intelligence is, how it works, how to use it in their everyday lives, and how it could potentially be used in their future"[1].

We discuss in this paper three of the most representative and promising courses for teenagers – secondary and mainly high school students. Students at this age are already close to the level of maturity, necessary to understand the philosophical and cognitive foundations of AI, as well as have the mathematical and technical knowledge that will allow them to understand an essential part of the classical and modern methods of AI.

2.1 AI4K12 initiative

The AI for K-12 initiative (AI4K12)[2] is aimed at developing guidelines for integration of AI in K-12 (12-year school education), a "curated resource directory to facilitate AI instruction" and "a community of practitioners, researchers, resource and tool developers focused on the AI for K-12 audience". It was launched in 2018 and is jointly sponsored by AAAI[3] and CSTA[4].

The AI4K12 guidelines are organized in so-called grade band progression charts that span separate K-2, 3-5, 6-8, and 9-12 grade bands. The educational content is still under development. It is organized in thematic units, united around "the five big ideas of AI":

- Perception,
- Representation and reasoning,
- Learning,
- Natural interaction,
- Societal impact.

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[1] https://www.coursera.org/learn/artificial-intelligence-education-for-teachers
[2] https://ai4k12.org/
[3] https://aaai.org/
[4] https://csteachers.org/

The educational resources developed[1] include a wide variety of books, book chapters, curriculum materials, videos, online courses, tutorials, demos, software packages, competitions.

AI4K12 is the largest initiative for the inclusion of AI in school education. It covers all school levels, and for each level defines age-appropriate goals and expected results from the acquisition of the provided knowledge and skills of each thematic unit.

2.2   CBSE AI curriculum for schools

- With the aim "to make the country AI-ready", the Central Board of Secondary Education (CBSE) of India has developed an AI curriculum for schools[2]. The CBSE AI curriculum focuses on building "an AI mindset and relevant skillsets and toolsets" and was launched in September 2019. Its content covers three main units:
- Introduction to AI, including AI ethics;
- AI project cycle, including data acquisition, data exploration, and modelling (rule-based and learning-based approach);
- Neural networks.

Thus the CBSE AI curriculum for schools introduces students to attractive areas of AI such as machine learning, computer vision, and natural language processing, as well as demonstrates how one can use the concepts learned to develop real-world based projects. It is suitable for young people aged 15-16 and more and in the 2019/2020 school year was successfully experimented in over 880 schools among more than 71 thousand students.

2.3   AI course at Blyth academy

The AI course at Blyth Academy[3] is the first high school credit Artificial Intelligence course in Canada. It was designed to give students an idea of both the philosophical and conceptual foundations and the practical sides of AI. The course syllabus includes six units:

- The nature of AI (with essential questions answered: "What is AI? Have humans created real AI? How can we test possible AI to decide?");
- Review of fundamental skills ("What are key programming skills needed to explore AI?");
- Linear regression ("How can we use linear regression to create machine learning?");
- Logistic regression ("How can we use logistic regression to create machine learning?");
- Artificial neural networks ("How can we create artificial neural networks?");
- Implications of AI ("How could artificial intelligence impact our future?").

As a useful side effect, students can acquire basic programming skills using Python. The path of learning ends with the development of a final project that requires knowledge of all the concepts studied.

The AI course at Blyth academy is designed for motivated high school students who have the ambition to learn how to use professional AI tools and how to build AI projects that solve real-life problems. Seems that there are very few AI courses for high school students at this level of depth and commitment to practical aspects, regardless of the relatively limited scope of its content.

3   Massive open online AI courses

MOOCs are free online courses available for anyone to enrol. They provide opportunities for millions of people to learn new knowledge and skills and in this way to advance their careers, to enrich their general culture, and to understand new trends in science and technology.

There are thousands of MOOCs, including more than 200 in AI and related areas. Among the most popular of these are the Finnish 'Elements of AI' course and the 'AI for everyone' course provided by Coursera.

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[1] https://ai4k12.org/resources/list-of-resources/
[2] http://www.cbseacademic.nic.in/web_material/Curriculum20/AI_Curriculum_Handbook.pdf
[3] https://blytheducation.com/blyth-academy-online/courses/idc4u-artificial-intelligence/

3.1   Elements of AI

The 'Elements of AI' course[1] is developed by the University of Helsinki and the Finnish technology company Reaktor and is currently recognized as one of the best MOOCs in the world.

The basic English version of the course consists of two parts: 'Introduction to AI'[2] and 'Building AI'[3]. The syllabus of the first part – 'Introduction of AI', includes six chapters, each of which is divided into three sections:

- Chapter 1: What is AI (How should we define AI, Related fields, Philosophy of AI);
- Chapter 2: AI problem solving (Search and problem-solving, Solving problems with AI, Search and games);
- Chapter 3: Real-world AI (Odds and probability, The Bayes rule, Naïve Bayes classification);
- Chapter 4: Machine learning (The types of machine learning, The nearest neighbour classifier, Regression);
- Chapter 5: Neural networks (Neural network basics, How neural networks are built, Advanced neural network techniques);
- Chapter 6: Implications (About predicting the future, The societal implications of AI, Summary).

The presentation is intended for users without any mathematical or computing or engineering background. It is illustrated with well-thought-out understandable and extensible examples from current areas of interest to people of different ages and professions.

The second part – 'Building AI', is "a flexible online course for anyone who wants to learn about the practical methods that make artificial intelligence a reality". It is a natural continuation of 'Introduction to AI' which at another level addresses the same topics (see Figure 1), but can also be studied separately. 'Building AI' is aimed at a more technically competent audience and allows to go into some depth in the basic concepts and methods of AI. It is suitable for high school students with a mathematics or natural sciences or technology profile, but its content is available to most students aged at least 15-16.
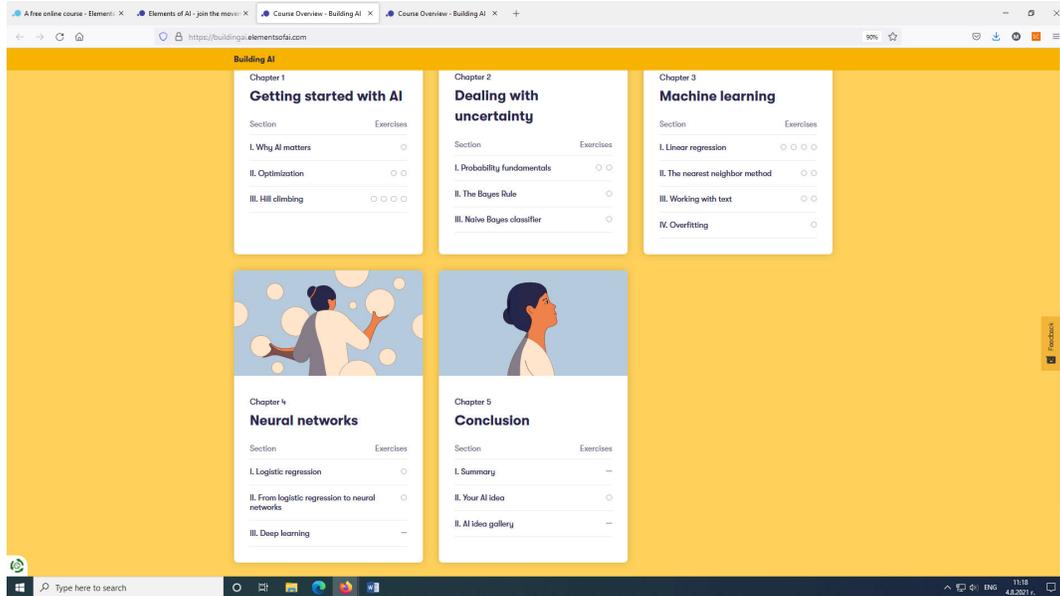

Figure 1: Syllabus of the 'Building AI' course

Both parts of the 'Elements of AI' course include a balanced number of appropriate exercises, which play an essential role in the adoption of the learning content.

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[1] https://www.elementsofai.com/
[2] https://course.elementsofai.com/
[3] https://buildingai.elementsofai.com/

During its EU Presidency in 2019, Finland decided to offer under the name 'Elements of AI' the introductory part of the course to all Member States in their official languages. This initiative aimed to give for as many people in the EU as possible access to the course content in a fascinating way and in a language of their choice, thus being attracted by the topics, issues, and opportunities revealed by the field of artificial intelligence. The Bulgarian version of the 'Elements of AI' course[1] was officially launched in February 2021. Figure 2 and Figure 3 illustrate the syllabus of this version.
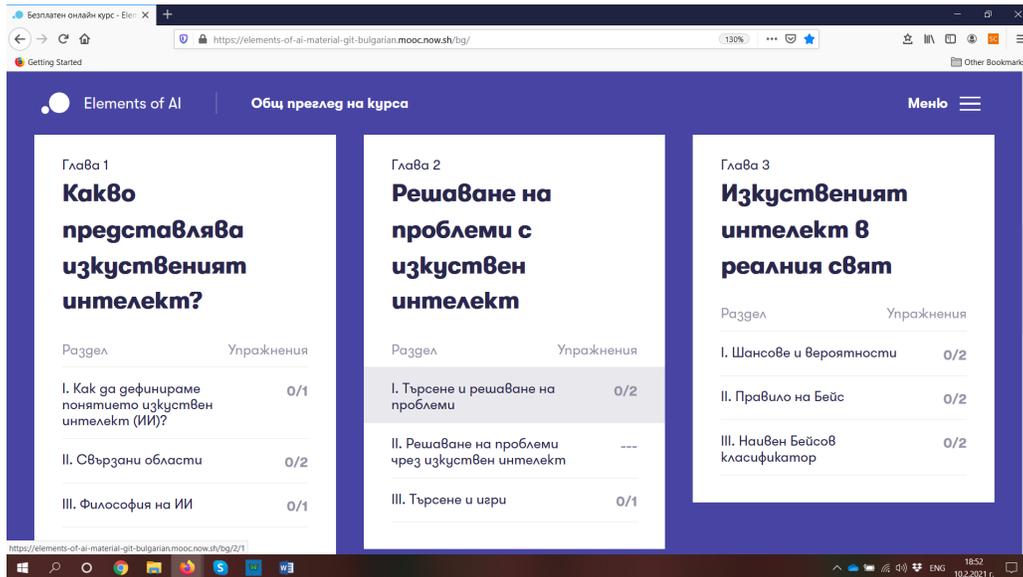

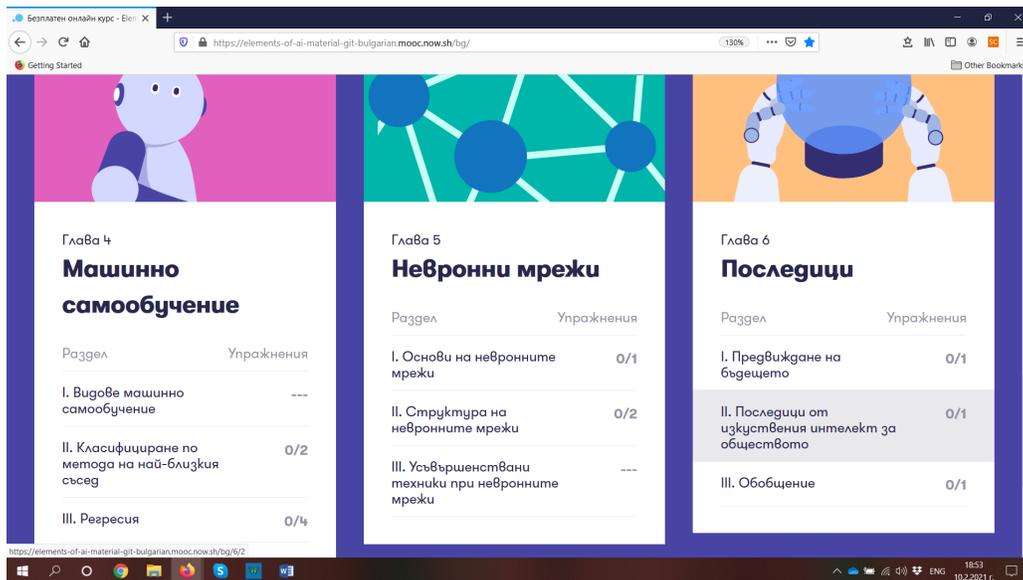**Figure 2**: Bulgarian version of the 'Elements of AI' course – syllabus (chapters 1 – 3)

Figure 3: Bulgarian version of the 'Elements of AI' course – syllabus (chapters 4 – 6)

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[1] https://www.elementsofai.com/bg/

By the end of May 2021, a total of 1,856 Bulgarian participants in the course were registered and 126 of them had already successfully completed it. Sofia University has gained extensive experience in disseminating this course both in academia and abroad.

3.2   AI for everyone

The 'AI for everyone' course[1] is designed by DeepLearning.AI and accessible through the Coursera platform. It is an introductory course which "will help you understand technologies like machine learning and deep learning and spot opportunities to apply AI to problems in your organization". The course content is organized in four parts:

- What is AI? (Introduction, Machine learning, What is data?, The terminology of AI);
- Building AI projects (Introduction, Workflow of a machine learning project, Workflow of a data science project, Every job function needs to learn how to use data, How to use an AI project, Working with an AI team, Technical tools for AI teams);
- Building AI in your Company (Introduction, Case study: smart speaker, Case study: self-driving car, Example roles in an AI team, AI transformation playbook, AI pitfalls to avoid, Taking your first step in AI, Survey of major AI application areas, Survey of major AI technologies);
- AI and society (Introduction, A realistic view of AI, Discrimination / Bias, Adversarial attacks on AI, Adverse uses of AI, AI and developing economies, AI and jobs, Conclusion).

Video recordings of lectures by the prominent professional Andrew Ng are provided as study materials. Each part is followed by an appropriate quiz.

Therefore, this course is suitable mainly for adults with non-technical professions who aim to understand machine learning and other AI-related concepts and techniques and to be able to use them for the improvement and modernization of their everyday work activity.

4   Conclusions and recommendations

The results of the study presented in this paper show that there is a good enough number of AI courses, suitable for secondary and high school students. Most of them, however, are too one-sided thematically. Their curricula do not adequately address key areas of AI such as planning, knowledge representation, and automated reasoning. The areas of natural language processing and natural language generation, as well as the one of computer vision, are also insufficiently addressed in most of the analyzed courses. All considered courses present in a balanced way the philosophical and cognitive aspects of AI on the one hand and the applied ones on the other. Due attention is paid to the legal and ethical issues of the creation of trustworthy AI systems and their implementation in the economy and social sphere, as well as in people's everyday life.

In our opinion, to develop a sufficiently flexible and adaptive AI course at the level of most Bulgarian high school students with a mathematics or natural sciences or technology profile, it is suitable to use as a basis a well-thought-out combination of the two parts of the 'Elements of AI' course, extended appropriately with topics from the following areas: Planning, Knowledge representation and reasoning, Natural language processing, Perception, Robotics. The presentation of the additional topics could be based e.g. on the corresponding chapters of [8]. In particular, reduced and properly simplified versions of Part III and Part VI of [8], enriched with appropriate examples, may be developed and used for the purpose.

The realization of this idea requires the creation of a lot of teaching and training materials in Bulgarian, consistent with the age, background knowledge, and life experience of students. A very useful resource in this regard can be the Bulgarian version of the 'Elements of AI' course. Certain textbooks issued at different times, such as [9] and [10], could be used as well. The materials developed and presented by Mr. Iliya Zhechev at the series of webinars in support of the participants in the Bulgarian version of the 'Elements of AI' course, which were broadcast live on the Sofia University

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[1] https://www.my-mooc.com/en/mooc/ai-for-everyone/

Facebook page[1], are an excellent guide that attractively offers a lot of information about the topics covered and can be used in different ways depending on the specific teaching aims.

For the implementation of more ambitious projects aimed at introducing AI courses in secondary and high school education, it is appropriate to study and analyze in-depth the experience of the AI4K12 initiative and the accumulated resources.

Acknowledgements

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