BUILDING KEY DIGITAL COMPETENCES IN AI STEAM EDUCATION AT SCHOOL

Todorka Glushkova, Anna Malinova, Sava Grozdev

Abstract. *The report will consider the possibilities of building key digital competences through Artificial Intelligence training within the framework of STEAM education at school. Different teaching approaches will be discussed on different topics related to the application, benefits and problems facing AI in today's world. Some ethical issues will be discussed and the authors' experiences will be shared.*

Key words: AI, STEM, STEAME, Digital Competencies.

Introduction

The rapid development of digital technologies determines the need for adequate changes in education [1]. Artificial intelligence is entering our lives more and more rapidly. Incorporating AI elements into traditional STEAM school subjects (such as mathematics, physics, chemistry, biology, etc.) requires curriculum change, which is a challenge for all education systems.

For the realization of these tasks, packages of strategic documents were created at the global, European, and national levels [2] concerning the study of AI in all degrees and forms of education. Based on the outlined trends, the DigComp framework [3] was created for the necessary digital competencies of EU citizens. In this framework, 5 groups of key competencies are defined, and for each of them, four levels of construction are defined: fundamental, intermediate, advanced, and highly specialized.

AI is an interdisciplinary field [7, 8, 9, 11], which accounts for the growing interest in AI education in interest groups in school STEAM centers. In the article, we will focus on the digital competencies of group 3. "Creation of digital content" and group 4. "Safety" in the aspect of school STEAM education in AI.

Challenges and approaches

There has been quite a bit of experience over the last few years in teaching AI in schools. Different countries around the world have intro-

duced the study of AI in different types of schools and at different levels of education. For example, many European countries such as Great Britain, Germany, Spain, Portugal, Netherlands, Greece, Portugal, etc. introduce the study of elements of machine learning for school students at the fundamental level. At the Massachusetts Institute of Technology in the US, a new AI curriculum has been developed that is applied to interest club training. The Indian government has launched several initiatives related to teaching AI as a compulsory school subject in high school. The experience in Australia, China, South Korea, Japan, etc. is also noteworthy. Interest clubs in STEAM centers are almost everywhere a preferred form of learning.

AI training has been taking place in our country for three years as a compulsory subject in innovative classes and schools; as an elective module in profiled and vocational high schools; or as learning in interest clubs in the STEAM school centers [4]. A curriculum has been developed, and the first teaching aids have already been issued.

Although the experience shows a high level of motivation and interest, the pedagogical community defines some significant problems that make the learning process difficult, such as [5]:

- In AI training, it is necessary to apply other approaches and another style of training, for which there are no trained specialists.
- Training takes place in different schools, different classes and in different forms, for which no suitable curricula have been developed.
- Lack of connection with students' knowledge of other subjects is a problem that can lead to excessive abstractness of the curriculum.
- Students' lack of background knowledge needed to understand AI algorithms.
- Insufficient preparation of teachers, which leads to overcomplication of teaching materials and demotivation of students.
- Diverse and sometimes difficult ethical problems.

Based on the experience gained in recent years, our team offers the following approach to solving these problems:

- Creation of a core curriculum, with clearly defined individual modules that can be studied in self-paced courses.

- Expanding the traditional teaching methodology
- Development of appropriate electronic resources, textbooks and aids.
- Organization of training and additional qualification of teachers.

Some of these tasks are solved through qualification courses and through the participation of our team in national and international projects (e.g. "Guidelines for facilitating the learning of Artificial Intelligence (AI) by School Students of Grades 7-12" – FACILITATE-AI [6]). Within these projects, we were able to develop training courses with appropriate teaching materials (Fig. 1).

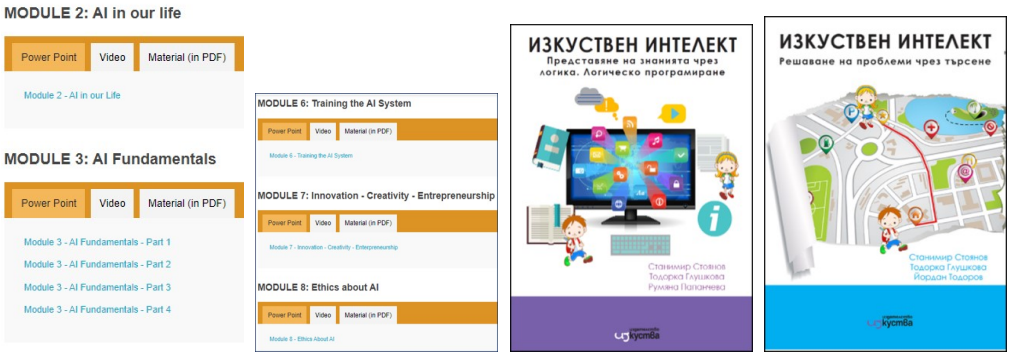

Figure 1. AI learning resources

With the aim of building the key competencies in group 3. Digital Content Creation, with the changes in the curricula and programs from the academic year 2018/19, compulsory training in computer modeling was introduced in our country from the 3rd grade of primary school. Programming using block programming environments is studied until the fifth grade, and in the sixth and seventh grades, it is gradually transferred to programming with scripting languages such as Python, JavaScript, etc. The programming of robotic devices (part of competence 3.2.) is implemented already in the fourth grade. The goal is for students to have covered the first basic level by the end of junior high school, and the second (secondary) level of these key digital competencies by the end of their school education.

AI training in STEAM interest clubs

STEAM learning includes some research practices that improve student achievement such as:

- Interdisciplinary training;
- Problem-based and project-based learning;
- Collaborative learning;
- Laboratory researches;
- Research projects involving solving real-world problems, etc.

Training in STEAM AI interest clubs provides an opportunity to build the target basic digital competencies.

AI training in interest clubs develop and addresses topics related to the use of search algorithms and route generation; defining strategies and finding optimal solutions; logical programming and representation of knowledge through logical rules; machine learning and audio and image recognition, etc. The application of this knowledge can be realized both by programming robotic devices and by developing educational games. To varying degrees and volumes, these topics are addressed by students in all age groups.

Building key digital competencies from group 3 in STEM centers is greatly facilitated by the fact that students have high motivation and interest in learning. Robotics is a desirable topic for students of different classes, levels, and age groups, and the application of basic AI algorithms to find a way out of a maze or to solve a certain problem helps to build the target digital competences (Fig. 2).

Figure 2. Robotics clubs in an experimental school

The development of games in which AI algorithms are used is also an interesting and entertaining topic for high school students. To make the

learning process more interactive, we use the role-playing game "Software Company" in teamwork [7]. The teams analyze the task, plan the execution, implement and test the game. The developed games are both for the concentration of attention, dexterity, and speed, as well as for training in various academic subjects. Building the digital competencies related to programming is further supported by learning several block programming environments such as SCRATCH, App Inventor, Alice, Blockly, etc. in compulsory or elective subjects. And mandatory 6th-grade Python programming makes it possible to create simple AI applications. Of particular interest is the possibility of creating games for mobile devices that take into account location and changes in the environment (Fig. 3).

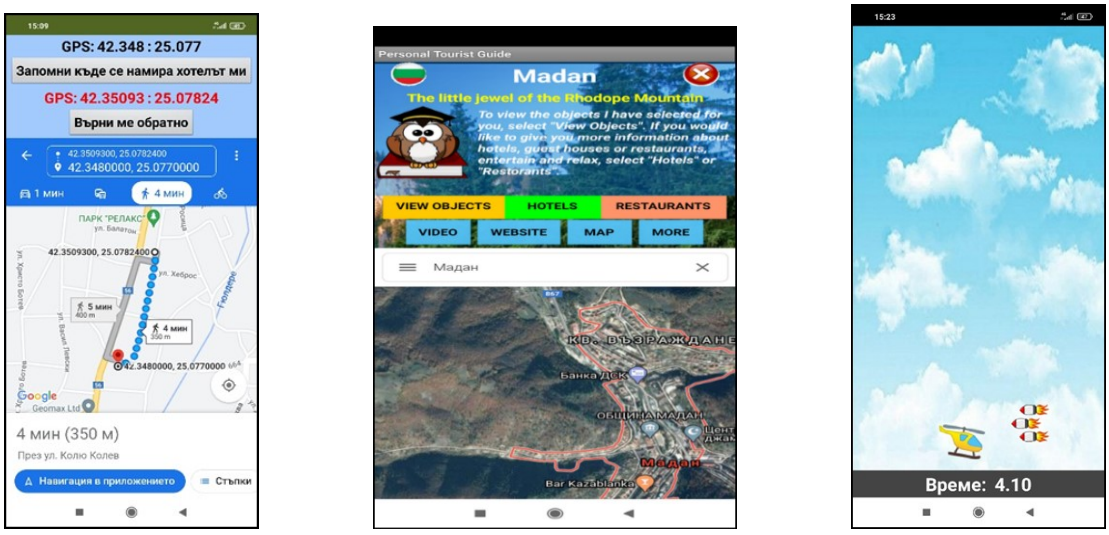

Figure 3. Apps and games for mobile devices

Since most of the students in the STEAM interest clubs have some experience in robotics, we also included in the experimental work the third-generation robot Robobo [8], which is specially designed for use in STEAM laboratories and aims to bring educational robotics closer to the applications of the real world [9]. The Robobo robot consists of a mobile platform and a tilt panel (PAN-TILT device) that supports a smartphone. Thanks to the tilting device, the robot can perform various movements such as shaking its "head", bending, turning, etc. and when these are combined with images displayed on the smartphone screen, sounds it produces, displacement of the main platform, use of different colored LEDs, the robot can express and convey emotions and feelings. Depending on the didactic goals, different programming languages can be used for programming:

Java, Scratch 3, Python and ROS (Robot Operating System). The sensors of the Robobo robot and the smartphone are able to sense changes in the environment and respond adequately. In addition, the processing power and memory required can continuously increase with the placement of a smartphone with better performance. Solving problems related to machine learning and image recognition (for example, pests in the school vegetable garden), as well as creating games that are "controlled" or assisted by the robotic device provide an excellent opportunity to increase the effectiveness of the learning process and achieve the desired levels in building the target key digital competences.

Figure 4. Application of AI in robotics and game development

Building the digital competences of Group 4. "Safety" of DigComp 2.2 is another important task in AI education at school. The "Ethics Guidelines for Trustworthy AI" [9] lists four ethical principles, which must be respected to ensure that AI systems are compliant with the fundamental rights:

- Respect for human autonomy;
- Prevention of harm;
- Fairness;
- Explicability.

Teaching AI in schools must introduce the European Union regulations of AI, the possible ethical problems of the AI systems, identify some vulnerabilities, and build thinking and awareness in students that will help them assess the levels of risk of using AI systems and as future developers build AI systems that are trustworthy and fair.

The use of pre-developed learning resources created in another context often leads to the emergence of undesirable results and conclusions

that are able to shape negative attitudes towards AI algorithms. In most cases, unacceptable results are the result of machine learning being conducted with an incorrect (or biased) dataset. Bias can arise in various ways and is one of the major factors for unfairness and violation of the trustworthiness of the AI. Some bias and discrimination examples are AI-enabled software systems in the areas of:

- CV-sorting software for recruitment procedures that leads to excluding groups of applicant;
- Migration, asylum, and border control management
- Essential private and public services (credit scoring software);
- Administration of justice and democratic processes – AI tools used to resolve a dispute or as a tool to assist in judicial decision-making;
- Education – software for exams scoring that may determine the access to education and professional course of someone's life.
- Building students' skills to recognize ethical issues and understand the reasons for their occurrence is one of the main tasks of AI education at school.

Examining relevant concrete real-life examples and situations in the training process in STEAM clubs is an effective way to build the digital competencies of group 4. "Safety".

Conclusions

As a result of the conducted experimental training and the accumulated (albeit not much) experience, we can claim that the motivation of students, teachers and parents is high, which gives grounds for more and more schools in Bulgaria to start AI training in some form - in a mandatory, elective, profiled form or as a STEAM interest club. Furthermore, we can argue that AI can be studied in all grades and even in mixed-age groups. The highest results are obtained in the interest groups at the school STEAM centers, where AI learning enables the building of the target digital competencies at basic, intermediate, and even advanced levels.

Interdisciplinary and problem-based learning in STEAM clubs creates a suitable environment for understanding and awareness of various ethical problems and the possibilities for their overcoming and resolution.

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