# Artificial Intelligence for Young Students: The Edu4AI Project Handbook

**C. Papasarantou[1], D. Alimisis [1], K. Geramani[2], G. Ioannidis[2], E. Theodoropoulos[1]**

[1]EDUMOTIVA
{cpapasarantou, alimisis}@edumotiva.eu
[2]IN2
{kg, gi}@in-two.com

## Abstract

This paper presents the educational content of "Edu4AI project handbook", a handbook with interdisciplinary AI projects produced in the context of Edu4AI Erasmus+ project, aiming to showcase practices that involve AI-based learning coupled with methodologies drawing on the Maker Movement trend and project-based learning. These AI projects were piloted in partner schools providing feedback regarding the educational value of these learning interventions. To set an example of the contained projects and the corresponding results of the evaluation, the "Control a DIY robotic car with voice commands" project is selected to be described and analyzed. It is argued that such projects can help students to become familiar with fundamental mechanisms of AI and ML, and acquire knowledge on how these concepts can be implemented in a meaningful way, thus developing essential life skills.

**Keywords:** Edu4AI, Artificial Intelligence, project-based learning, robotic car

## *1. Introduction*

Edu4AI (Artificial Intelligence and Machine Learning to foster 21st century Skills in secondary education) is an Erasmus+ project (www.edu4ai.eu) targeting at developing methods and techniques that can lead to a smooth and meaningful incorporation of Artificial Intelligence (AI) and Machine Learning (ML) practices into the school curriculum. This paper presents the educational content contained in the "Edu4AI project handbook", a handbook produced in the framework of the aforementioned Erasmus+ project. The handbook includes eight interdisciplinary AI projects showcasing AI-enhanced apps and intelligent artefacts that were developed through the implementation of various and age-appropriate AI-related services, technologies and tools. These projects aim to stress out practices and methods that involve AI-based learning with creative hands-on experiences, coupled with

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methodologies that draw upon the Maker Movement trend (Blikstein, 2013) and project-based learning practices, leading to the acquisition of 21st century skills. Towards this direction, each one of the included projects is enhanced with relevant Open Educational Resources (OERs) for both educators and students, such as teacher's guidelines, students' worksheets and videos, functioning as means for better communicating the scope of these projects, thus supporting student's learning in these fields. All the projects were piloted in partner schools, providing valuable feedback regarding the implementation of these learning interventions, through the documentation of their experiences.

To set an example of the developed projects contained in the handbook and the outcomes of the evaluation, the "Control a DIY robotic car with voice commands" project is presented. The project revolves around the idea of creating an Arduino-based robotic vehicle that is navigated/controlled through voice commands received (and transmitted) by an application designed in MIT App Inventor software. The project was implemented and tested with 37 students who attend the partner schools. Based on the outcomes of the evaluation, it is argued that such projects (i.e., projects that are engaging students in real-world scenarios and problems, as well as in hands-on practices) can help students to become familiar with fundamental mechanisms of AI and ML, and gain knowledge on how these concepts can be implemented in a meaningful way, thus developing essential life skills.

## *2. The Edu4AI Project*

The project has started in November 2019 and brings together the expertise of partners in 4 European countries within a team of both AI experts and school teachers. The piloting of the concepts and developed curricula in schools in all project-sites has given the opportunity of a fruitful cooperation and exchange of ideas between the experts involved. The selected projects cover different aspects of artificial intelligence and offer a broad overview for students and teachers of what is feasible and available in artificial intelligence focused on secondary education.

The core methodology of the project covered five main phases: the design of the pedagogical framework, the preparation of the technical specifications, the training of the teachers, piloting of the projects in all the sites of the project and the documentation of the experiences and good practices. We aim through the publication of the project's results to motivate and give the opportunity also to other schools to introduce AI in their curricula.

EUD4AI started at a time where similar attempts of introducing AI in schools have been reported worldwide. Unesco in 2019 (Unesco, 2019) by recognizing the potential of AI to transform the educational methodologies has published the "Consensus on Artificial Intelligence and Education" and created an international

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advisory board for helping its member countries by developing resources and workshops around AI.

In the United States the AI4K12 initiative (AI4K12, 2020) proposed guidelines and standards for designing AI curricula. In South Korea (APFC, 2021) there are national level plans to introduce AI in secondary education while in Canada there are reported local and civil society initiatives. Similarly, also in China (Chiu et al, 2022) cooperative teams from university teachers and principals from secondary schools co created a framework for AI lessons. All these attempts worldwide respond to the rapid developments in the AI field and also to the necessity of introducing technology in teaching and learning, something that has become more evident after the two years Pandemic.

## *3. The Edu4AI Handbook*

The Edu4AI handbook includes eight projects, revolving around the field of AI and ML. These projects were produced in the framework of Edu4AI Erasmus + project. Their aim is to showcase AI-enhanced apps and intelligent artefacts that were developed through the implementation of different AI-related services, technologies and tools. The eight projects were designed by the partners, constituting the EDU4AI partnership, and were piloted by the partner schools. Apart from the eight projects, the handbook also contains a number of lessons aiming to familiarize educators and students with fundamental mechanisms and methods of the field of AI and ML.

In order to decide upon the projects that would be developed we asked for proposals from partners including the partner schools. Initially, we encouraged all the partners to express and share their reflections and ideas during the first training, which was carried out online in March 2021. All the ideas were recorded and further discussed during next meetings. To ease the process, a template was provided in which the partners were encouraged to provide a short description of their proposed project, emphasizing also on the technologies and tools that would support their ideas, leading to a better categorization of them regarding the use of different AI services (i.e., voice recognition, printed text recognition, text to speech, image classification, emotion recognition, chatbots, Programmable AI Toys). In this way 23 different scenarios and projects were collected. Among them eight projects covering different aspects of AI in education were selected to be further developed. The selected activities were in line with the pedagogical considerations and methods that were highlighted earlier in the Edu4AI project. Another crucial parameter that was taken into consideration was pluralism and the age appropriateness of tools and AI services that would be used for the implementation of these projects.

The selected projects were further developed and enhanced with relevant OERs targeting both teachers and students. In particular, each project contains a scenario inspired by real-life cases, accompanied with a number of learning objectives

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capturing the knowledge, the skills, and the attitudes that students should be able to exhibit as well as the addressed sustainable development goals. Information regarding the learning, the hardware and software prerequisites, as well as a time plan about the estimated duration of each project are also incorporated. Additionally, in order to facilitate the implementation of each project, a number of OERs in the form of teacher's guidelines (composed of pedagogical tips and considerations, as well as programming and implementation solutions), students' worksheets (containing a number of tasks and activities to ease the realization of the projects) and evaluation tools (short questionnaires for gathering feedback by the participant students and teachers) are designed and provided as external files.

The projects were piloted in partner schools providing valuable feedback regarding the implementation of these learning interventions, through the documentation of their experiences, and during discussions with teachers who piloted the projects, leading to lessons learned and the final refinement of the handbook. This feedback was recorded and collected through online evaluation forms filled by the teachers and the students who participated in the pilots, as well as in the framework of teacher training.

## *4. Setting The Example Of The "Control a DIY Robotic Car With Voice Commands" Project*

One of the projects included in the handbook is the "Control a DIY robotic car with voice commands" project (Figure 1). This project revolves around the idea of creating an Arduino-based robotic vehicle with some degree of automation. An autonomous vehicle is defined as a vehicle with a fully – or partially – automated driving system, able to perceive its environment and correspond to external stimuli based on data inserted by a human driver/user (Technopedia, 2021). In this project, the external stimulus is a human voice giving navigational commands. These (voice) commands are received by an application designed for smart devices (such as smartphones and tablets) in MIT App Inventor software, and transmitted to the robotic car using Bluetooth (Figure 1).

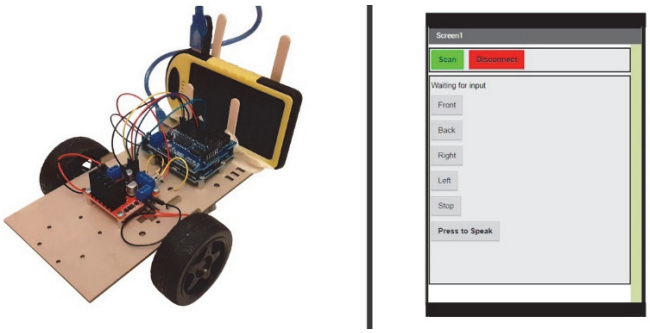


**Figure 1.** *Left: Image of the DIY robotic car; Right: Preview of the application*

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Specifically, the driver will be able to instruct the DIY robotic car to move forwards and backwards, as well as to turn (right or/and left), but also to stop whenever is necessary. Through this scenario a number of parameters can be explored such as the responsiveness of the vehicle to the voice commands, and the obstructions that noises and mispronunciations can create. In this way, students can become aware of the importance and the risks of using voice commands to add automation to driving.

### *4.1 Learning Objectives*

It is argued that through this project students will be able to define/explain what an autonomous vehicle is, and to discuss different aspects of integrating AI to a project through voice recognition and voice commands. Also, they will be able to identify and discuss advantages and risks of implementing voice commands in driving, as well as to explain basic programming concepts regarding the implementation of speech-to-text services. Additionally, students will learn to construct a robotic artefact and create electrical circuits as part of a robotic construction, reflect their ideas through programming and use programming commands coupled with AI methods to address a specific behavior to the robotic artefact. Moreover, they will learn to experiment with alternative solutions, as well as exchange ideas and views in teams regarding emerging challenges.

Also, it is expected that students will develop self-confidence in applying AI programming methods, and especially those related to speech-to-text services, while valuing the risks of using AI technologies. Moreover, since team work is encouraged for the implementation of this project, it is expected that students will learn how to collaborate, and find solutions on the emerging problems as a team. Finally, they will be able to develop strategies that will reduce inequalities by providing solutions for people with motor disabilities regarding driving a car, while they will learn to promote innovative solutions regarding navigational systems.

### *4.2 Prerequisites*

Regarding hardware, and in order to realize this project, an Arduino board and a number of compatible electronical components, as well as a number of materials that will enable the construction of the robotic car, are needed.

Concerning software, Arduino IDE environment (https://www.arduino.cc/en/software) is needed for programming the robotic car, and MIT App Inventor (https://appinventor.mit.edu/) for creating and programming the application. Also, mBlock block-based programming environment (https://mblock.makeblock.com/en-us) is suggested for familiarizing students with programming and for a smooth transition from block-based to text-based coding.

As far as learning prerequisites are concerned, even though the provided OERs can fully support the implementation of the project without any previous experience, it is

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highly recommended that the students should be familiar with block-based coding and the Arduino IDE environment. Some good practices for introducing Arduino IDE coding to students are also suggested in the handbook.

### *4.3 Time Plan*

The project was estimated to be completed in 8 hours, divided in 4 sessions (i.e., 2 hours per session). In particular, it was estimated that students will be able to complete the entire structure of the robotic car (i.e., crafting and circuitry) within 2 hours (1st session). Then, they would need 2 more hours (2nd session) for doing warm up activities (in order to become familiar with programming processes) and program the robotic car. After that, they would need 4 more hours in total (3rd and 4th session) to create and program the application through which the robotic car will be controlled. All the aforementioned steps were intended to be performed in teams of 3 or 4 students. To ease the process, students' worksheets would be provided in each one of these teams, while teachers would move around, assisting them or giving tips whenever it was necessary.

### *4.4 Piloting The Project: Feedback and Evaluation Results*

This project was implemented by 37 students, ages from 15 to 17 years old, in two different countries (i.e., Greece and Spain). Due to Covid19 restrictions, the implementation was made in teams of 2 or 3 students, who shared the tasks. The students who implemented this project did not have any previous experience in working with Arduino technology, but they have some experience in programming. Therefore, the teachers (who were mostly Computer Science teachers) had to offer introductory lessons not only on Arduino technology but also on Arduino IDE software. They also did some introductory courses to familiarize students with AI concepts, as well as to smoothly introduce them to the MIT App Inventor environment. Even though both teacher's guidelines and students' worksheets, as well as the provided audiovisual materials (e.g., video for crafting the robotic car etc.), were considered as very helpful resources, more research was necessary to tackle emerging difficulties and problems. For these reasons, the project was perceived by both teachers and students, as a project of average difficulty. Specifically, in the question "how easy or difficult was this project for you?", in a scale of 1 (very easy) to 5 (very difficult) the majority of students answered 3, while the mean average was equal to 3,03 (Table 1).

Due to the aforementioned parameters, the actual time needed for completing the project varied from 20 to 30 hours. Nevertheless, teachers reported that the students did really like this project and enjoyed the entire process towards the realization. This statement is also reflected in the answers of the students to the question "In a scale of 1 (not at all) to 5 (a lot) how did you like this project", since the majority of them answered 4, getting a mean average equal to 4,08 (Table 1).

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**Table 1.** *results from students' questionnaires*

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| In a scale of 1 (not at all) to 5 (a lot) how did you like this project | 0 | 0 | 4 | 26 | 7 |
| In a scale of 1 (very easy) to 5 (very difficult) how easy or difficult was this project for you | 0 | 9 | 18 | 10 | 0 |

According to teachers, one of the most valuable aspects of this project was the gained knowledge on working with Arduino board, and combining crafting and programming in order to find solutions for real world problems. Regarding AI, teachers reported that students did realize how to use AI for this specific project, but they didn't understand in depth the mechanisms laying underneath this concept, namely how speech-to-text AI services function.

These statements are also reflected in the feedback received by the students. Regarding how comfortable/confident they felt to explain different aspects of AI and ML after the implementation of this project (Table 2), the results indicate that the majority of students felt a bit confident with these concepts. In particular, and regarding explaining what AI is, there were 10 students who replied 'Yes' and 25 'A bit'. Concerning their feelings towards explaining how AI can be used in real life, 15 students chose 'Yes' as an answer, and 19 'A bit'. These numbers were slightly changed when the students were asked to express how comfortable they were feeling to explain what ML does. In that case, there were 10 students who replied 'Yes', and 20 'A bit', but there were also 7 students who declared that they did not feel comfortable at all on explaining what ML does, after the realization of this project. This is quite reasonable, since there wasn't any implicit or explicit reference to ML in this particular project. As far as feeling comfortable on experimenting with AI projects, and building and programming an AI artefact is concerned, 24 students declared feeling 'A bit" confident and 10 of them replied 'Yes'.

**Table 2.** *results from students' questionnaire reflecting their attitude towards AI and ML*

| After this project I feel comfortable to | Yes | A bit | Not at all | Not applicable |
|---|---|---|---|---|
| explain what AI is | 10 | 25 | 2 | 0 |
| explain what ML does | 10 | 20 | 7 | 0 |
| explain how AI can be used in real life | 15 | 19 | 3 | 0 |
| experiment with AI projects, building and programming an AI artefact | 10 | 24 | 2 | 1 |

Concerning the use of gained knowledge and skills in a similar project, 30 students claimed that they might apply them in the future and 6 of them answered that they will definitely apply them in the future (Table 3). Regarding motivation on learning more about AI, 17 students declared that they have been definitely motivated, 16

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answered that they might be motivated, 3 claimed that they were definitely not being motivated and 1 wasn't sure, or didn't know at that point. Based on the feedback received by the teachers, these results can be interpreted as a rather positive attitude of the students towards these aspects.

**Table 3.** *results from students' questionnaires regarding gained knowledge and motivation*

| | **Definitely Yes** | **Maybe** | **Definitely No** | **Don't know/ Not sure** |
|---|---|---|---|---|
| I feel I can use the gained knowledge and skills in new similar projects | 6 | 30 | 1 | 0 |
| The project has motivated me to learn more about AI | 17 | 16 | 3 | 1 |

Teachers also suggested a number of improvements for optimizing and assisting the organization and the implementation of the project. Some suggested improvements were about the crafting and the circuit making process, such as making available 3D models of chassis (for 3D printing), or adding circuit maps with alternative solutions regarding power supply, thus permitting flexibility in construction and circuitry. Some other suggestions were about enhancing the existing resources with extra links for smoothly introducing different aspects of the project, thus reducing the time of extra research (e.g., adding to teacher's guidelines links to introductory tutorials for some of the proposed software, in case students have no previous experience on programming). Regarding the process of implementation, oral tests in the form of discussion in critical parts of the project, were suggested as a method for making students more aware towards the use of AI and ML concepts. In this direction, changing roles was also suggested, giving the opportunity to students to be involved in all the implementation phases.

## *5. Reflections and Recommendations*

In general, and according to the feedback received through the evaluation forms (i.e., questionnaires) by both teachers and students, but also through the experiences that were shared by teachers, the "control a DIY robotic car with voice commands" was a project that students really enjoyed, even though it was perceived as a project of average difficulty, and despite the problems they faced during the implementation. Through their involvement in a scenario inspired from real life, students learnt how to use crafting and programming, coupled with the use of AI services (i.e., speech-to-text services), in order to find solutions to real world problems. This was also a reason that – according to teachers reports – kept students' interest at a high level during the entire project, even though the initial recommendations were probably highly estimated. Another important aspect that was highlighted was that students managed

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to smoothly collaborate in order to successfully implement the project, and they even helped other teams in case they were finishing their tasks earlier.

Examining the after effects of this project on perceiving AI and ML concepts it was noted that students felt a bit confident on explaining what these fields are about and how they can be used in real life. According to the teachers report, this lack of self-confidence (towards the aforementioned concepts) is not related to the content of this specific project but to the fact that students could not fully understand the mechanisms laying behind these concepts. In their opinion a longer introductory course to AI would probably lead to an easier understanding of the immanent concepts. And since the "Control a DIY robotic car with voice commands" was the first AI project that students implement, this lack of self-confidence is perceived as a normal reaction. Also, based on the outcomes regarding their motivation on learning more about AI, it can be argued that students started to develop a positive attitude towards these concepts and were encouraged to further explore these fields.

Based on all the aforementioned results, it is argued that such projects (i.e., projects that are engaging students in real-world scenarios and problems, as well as in hands on practices) can pave the way towards familiarizing students with fundamental mechanisms of AI and ML, and obtain knowledge on how these concepts can be implemented in a meaningful way. Furthermore, they help students to gain communication and collaboration skills, be creative and take decisions and also prepare them for the future labor market which is expected to be significantly disrupted from the AI.

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# Τεχνητή Νοημοσύνη για Μαθητές: το Εγχειρίδιο "Edu4AI Project Handbook"

**Χ. Παπασαράντου, Δ. Αλιμήσης, Κ. Γεραμάνη, Γ. Ιωαννίδης, Η. Θεοδωρόπουλος**

**Περίληψη**

Το παρόν κείμενο αναφέρεται στο "Edu4AI project handbook", ένα εγχειρίδιο με διαθεματικές εκπαιδευτικές δραστηριότητες γύρω από την Τεχνητή Νοημοσύνη (ΤΝ) που αναπτύχθηκαν στα πλαίσια του έργου Edu4AI, ώστε να παρουσιάσουν πρακτικές που συνδυάζουν την μάθηση της ΤΝ με μεθοδολογίες του Κινήματος των Δημιουργών (Maker Movement) και της μάθησης βασισμένης στα projects. Οι δραστηριότητες αυτές εφαρμόστηκαν πιλοτικά σε σχολεία, δίνοντας ανατροφοδότηση για την αξία τέτοιων μαθησιακών παρεμβάσεων, από εκπαιδευτική σκοπιά. Υποστηρίζεται ότι τέτοιου είδους δραστηριότητες βοηθούν στην εξοικείωση των μαθητών με βασικούς μηχανισμούς της ΤΝ, οδηγώντας στην ανάπτυξη χρήσιμων δεξιοτήτων για την καθημερινή ζωή. Το επιχείρημα αυτό υποστηρίζεται μέσω της αναλυτικής περιγραφής της δραστηριότητας με τίτλο "Ελέγχοντας ένα ρομποτικό αυτοκίνητο με φωνητικές εντολές".

**Λέξεις κλειδιά:** Edu4AI, Τεχνητή Νοημοσύνη, μάθηση βασισμένη στα project, ρομποτικό αυτοκίνητο

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