EDU4AI

HANDBOOK WITH AI PROJECTS

Edu4AI -- Artificial Intelligence and Machine Learning to foster 21st century Skills in secondary education

IO3: Handbook with AI projects

Edu4AI -- Artificial Intelligence and Machine Learning to foster 21st century Skills in secondary education

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Introduction

What this handbook is about

This handbook includes eight projects, revolving around the field of AI and machine learning, that were produced in the framework of EDU4AI Erasmus + project. The aim of these projects 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 the field of AI and machine learning. Moreover, the produced material is enhanced with relevant Open Educational Resources (OERs) for both educators and students, such as teacher's guidelines, students' worksheets and videos. Additionally, following the feedback provided by teachers and students during the piloting of the projects in the partner schools (finalized in June 2022) and the training course (July 2022), the present handbook addresses refinements and lessons learned.

The following sections present:

1. the adopted methodology towards the proposition and selection of the eight AI projects,

2. a quick glimpse at these projects through a short synopsis describing what each project is about,

3. an introduction and overview of artificial intelligence through a collection of 18 lessons (project 0), putting forward the basic concepts of artificial intelligence (including machine learning) in school classes,

4. detailed description of each project including material for assisting teachers and students and facilitating their implementation in class

5. refinements and lessons learned from the evaluation of the piloted project.

Our methodology

Nowadays, there is a wide variety of AI & ML technologies that could be selected for supporting students' learning in these fields. Through a number of online tools, students can become familiar with basic/fundamental mechanisms of AI and ML, understand how they work, and ideally build some relevant experience. However, this knowledge and the concepts laying underneath, remain rather abstract, if students' work is limited to a virtual (computer-based) and abstract form. Students, especially younger ones, tend to struggle to fully grasp abstract AI concepts, if they cannot apply them in real-life through tangible experiences and methods. Therefore, it is important that learning AI & ML will provide an authentic connection to students' everyday life through real world problems and/or challenges. In this sense, in the EDU4AI project partnership we strongly believe that the best results might come from a project-based learning method that would introduce AI & ML in a playful and hands-on way. Moreover, considering the required school time and effort of teachers and students, we believe that learning and implementing some (and not necessarily all) of the available AI & ML techniques can still lead to the implementation of a wide variety of projects, in which more time for creative project work will also be fostered.

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 thoughts and ideas during the first training (C1), 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).

All the proposed ideas were hosted on a shared folder on google drive, facilitating the discussion towards the selection of those that would be further extended and piloted. Table 1 lists all the suggested scenarios (23 in total) sorted by the title of each project, the AI category and the age group that belongs and refers to as well as the partner who made the proposal.

Based on these proposals, eight projects covering different aspects of AI in education were selected to be developed. The feedback of the partner schools (namely EPAL, JKG and SANT ROC) toward the selection of these projects was crucial, while the selected activities were in line with the pedagogical considerations and methods that were highlighted in the context of IO1, as well as the services and tools that were included in the context of IO2. In this sense, another crucial parameter that was taken into consideration was the pluralism and the age appropriateness of tools and AI services that would be used toward the implementation of the projects.

The selected projects were further developed and enhanced with related 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 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 related 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 implementation 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 lessons learned, leading to the final refinement of the present handbook and the relevant resources. This feedback was recorded and collected through online evaluation forms filled by the teachers and the students who participated in the pilots, and trough discussion with teachers who participated in the C3 training course and shared their experiences.

Review of scenarios for projects that result in AI- enhanced apps and artefacts proposed by partners			
Title	**AI category**	**Age group**	**Partner**
Board AI Game	Intelligent Robots & Toys	12-18	AIJU
Learning new Languages	Text to Speech translation	12-18	AIJU
Smart Classroom	Voice Recognition	15-18	AIJU
Deciphering hieroglyphs	Printed Text Recognition	15-18	AIJU
Face recognition	Image Recognition	15-18	AIJU
Control a DIY Robotic car with voice commands	Voice Recognition	15-18	EDUMOTIVA
Open sesame – Covid19 safety rules	Machine learning, Computer Vision	13+	EDUMOTIVA
Self-driving DIY robotic car	Image Recognition	15-18	EDUMOTIVA
Turning audio to visual signs	Sound Recognition & audio classification	15-18	EDUMOTIVA
Autonomous driving vehicle	Image Recognition	15-18	FMD
Heath AI application: Poses recognition in rehabilitation	Pose Recognition	15-18	FMD
Regoliamoci	Programmable AI toys	12-15	FMD
Voice recognition with Arduino board	Voice Recognition	15-18	FMD
Waste sorting App	Image Recognition	15-18	FMD
Art Curator	Image Recognition	15-18	EPAL
The manikin needs some kind of medicine	Intelligent Robots & Toys	16-18	EPAL
Technical draughtsman	Image Recognition	15-18	EPAL
Introduction to decision trees	Algorithms	14+	JKG
Introduction to k-Means	Algorithms	14+	JKG
Introduction to k-Means Clustering	Algorithms	16+	JKG
Introduction to Machine Learning Pipeline	Process Knowledge	12+	JKG
Image – Attendance list	Image Recognition	15 -18	SANT ROC
Virtual Secretary's Office	Chatbot/ Text Recognition	15 - 18	SANT ROC

Table 1: the 23 suggested scenarios

(More info for each suggestion can be found here)

A quick glimpse at the 8 AI projects

1. Synopsis of project 1: control a DIY robotic car with voice commands

This project is about a futuristic semi-autonomous vehicle that is controlled by the driver's voice commands. After short research on topics related to the current state of voice assistant applications embedded in cars, coupled with the integration of AI, it was noticed that there is still work to be done on using voice commands as a primary method for controlling and navigating a car. Therefore, the present project is proposed in order to explore this quite challenging but also promising feature. Through the DIY robotic car, a number of crucial parameters, such as the responsiveness of the vehicle to the voice commands, as well as the obstructions that noises or mispronunciations can create, will be investigated, making students aware about the impact (advantages and risks) that the implementation of such technology can have. By the end of the project, students will gain significant knowledge, skills and attitudes towards approaching and solving a real-world problem.

2. Synopsis of project 2: Autonomous driving vehicle recognizing traffic signs

Self-driving cars and robotic vehicles use AI to move safely in the environment. By sensing the environment, they can identify obstacles, the shortest paths, and make decisions autonomously.

In this project, students will reflect on self-driving cars and related technological and ethic challenges; after exploring AI basic concepts they will focus on computer vision aspects and learn about image classification and object recognition. Students will train a model that classifies street sign images using AI image classification services. They will create their own DIY vehicle capable of recognizing autonomously street signs and signals adapting its behavior using their trained model.

3. Synopsis of project 3: Virtual Secretary office chatbot

In this project a Chatbot will be developed, functioning as a virtual assistant that will automatize the hard, tedious, and repetitive tasks and activities, such as answering to frequent questions related to students' registration, thus saving time to secretaries.

By using programming environments designed for creating Chatbots, the students will be able to acquire some basic programming skills, which can be further developed, thus enabling them to create Chatbots that perform different and more complex functions.

This project stresses the importance of Artificial Intelligence in our daily life and ways that students can benefit from such tools that will ultimately determine their future in the 4.0 revolution.

4. Synopsis of project 4: Face recognition

This project revolves around face and emotion recognition. Initially, the students learn how to create and program an emotional recognizer application that will be able to recognize facial expression, by using the mBlock block-based programming environment (basic solution). Then, based on their experience, they are encouraged to get involved in a more advanced solution through which they learn how to develop a facial recognition system, by using the Anaconda programming environment. Through this project, students will not only acquire skills in Artificial Intelligence, but will also learn the importance of data processing, and in particular, of image pre-processing. Another aim of this project is for students to improve their programming skills and develop logical thinking, providing them competence in the future labor market, which is expected to be closely linked to programming and Artificial Intelligence.

5. Synopsis of project 5: Open Sesame

Students learn about Computer Vision and Artificial Intelligence (AI) by creating and training their own Machine Learning (ML) model with Google Teachable Machine to recognize whether or not a person is wearing a Covid-19 mask. Using Pictoblox software to upload their trained ML model and connecting it to an Arduino microcontroller, they implement a face-recognition automated door which will open only if a person follows the Covid-19 safety rules. They raise awareness on the Sustainable Development Goals 3 (Good Health and Well-being) and Goal 16 (Peace and Justice Strong Institutions) and understand the need to use technology for good, in order to solve real-life problems while respecting and protecting basic human rights.

6. Synopsis of project 6: Voice recognition with Arduino board

Voice recognition technology is a newborn technology which allows us to quickly turn speech into written text. Voice command devices have grown to a very advanced level beyond our expectations in a very short time. Amongst the best-known applications in this field, we can mention voice assistance (e.g., Google assistant, Amazon Alexa, etc.).

In this project, students will learn about voice recognition as an application of AI and will create their own app by using an Arduino Uno board and a V3 voice recognition module.

Students will train a model that recognizes words, through the IDE (programming environment) of Arduino. They will use their trained model to create an artefact that turns on/off a LED or a light, activates a buzzer or other devices, implementing voice commands.

7. Synopsis of project 7: Device that turns sounds to visual signs

This project revolves around the idea of creating an electronic device – for domestic use – that will visually notify people with hearing loss for significant audible events happening in their house (e.g., sound of an alarm, a doorbell etc.). The electronic device will receive data from an application designed in MIT App Inventor software, which will record and classify the incoming sounds. The classification of sounds will be made through the Personal Audio Classifier training environment; an application that produces trained models compatible with the “Personal Audio Classifier” extension of MIT App Inventor. The electronic device is an Arduino-based device and is programmed through Arduino IDE software.

8. Synopsis of project 8: Health AI application: poses recognition in rehabilitation

(Conceptual project)

In this activity, students will learn about body schema detection in order to create their own app based on dance and on gamification techniques. To this aim, students will train a model that uses an online teachable machine.

Students will use their trained model to verify a posture during repeated exercises. Finally, students will create an app through Scratch (or a more complex environment, according to their previous knowledge and competences) which can help patients to engage in rehabilitation therapy.

Note: this project was developed as an extra project for enriching the content of the present handbook. Therefore, it was not piloted to partner schools, but it is highly recommended for being implemented with students since it is introducing, among others, the notion of gamification as a method for becoming familiar with AI and ML.

Introduction and overview of artificial intelligence (Project 0):

A collection of lessons for introducing the basic concepts of artificial intelligence / machine learning in school classes.

Organization: JKG

Author: T. Jörg

Why this teaching unit?

Artificial intelligence and machine learning: now ubiquitous and an integral part of our lives. This area of technology is a two-sided sword: On the one hand, it opens up entirely new possibilities, for example in the detection and treatment of diseases. On the other hand, it is used to explore all of our lives and discover hidden behaviors that we ourselves are not aware of.

Basic thoughts about the structure of the lessons

But how does it work? Understanding how this fascinating technology works from the ground up requires access. An access that needs to be opened up: at best by competent teachers and a teaching concept that goes through both the basic mindset and the individual functional units, explains them in simple steps and thus makes them understandable in depth.

Understanding students' fears and empowering them

Artificial intelligence is considered highly complex. In my experience as a teacher for this field, I have therefore encountered anxiety in students a few times: "Am I even capable of understanding these complicated relationships?" I was recently asked this by a highly gifted fifteen-year-old student who was hesitant to come to my ML class. Yes, of course you can understand! Artificial intelligence theories and methods are man-made and therefore they are understandable to humans.

The common thread of the course

The basic concepts start with collecting data: Artificial intelligence is often experiential learning. And data carries the information of this experience. But: which data is relevant, which parts can be sorted out? What methods does a computer use to process this pre-sorted, relevant data? How do these methods (called "algorithms" in technical terminology) work? What do you do with it when a computer has finished learning? These questions are taught, applied and practiced in structured, sequential lessons.

Possible pitfalls and how to avoid them

It is not necessary to program; it should even be actively refrained from by the teacher! In the didactics of computer science, one separates computer science principles from the implementation in concrete programming languages. This is because it would require the student to concentrate on two areas at the same time. Therefore, the lessons are based on everyday experiences, visual simulations, short calculation and puzzle tasks and the no-coding software "Orange Data Mining".

Get started!

To date (as of April 2022), the lessons have been taught, tested and evaluated five times at different grade levels. They are intended to serve as a guideline, as inspiration. We hope you have fun trying them out!

Lesson 1:

Why should young students study the basic concepts of A.I.? Some introductory thoughts for teachers

This introductory lesson contains some preliminary thoughts for teachers regarding the reasons that students should study the basic concepts of A.I.

Click here for Lesson 1

Lesson 2:

ML /AI / DL What's behind it all?

A. I. is all around us, we find it – sometimes invisible, hidden – in many places and applications. It's about predicting things, forecasting*, pattern recognition and rule-based synthesis of new unknown things (Style-GANs or Transformer Models). Students should understand the relevance of A.I. in their life.*

Click here for Lesson 2

Lesson 3:

Classification & prediction, what about data privacy protection?

What students should learn in this lesson:

Data is collected from me as an individual through many different channels: Via social networks, by means of movements with my smartphone, and even movement profiles within supermarkets. All this data is used by trained artificial intelligences to create personality profiles of me. These make it possible to make my thinking and future trading transparent to outside institutions. And often others know about my habits that I am not aware of myself. This is where you have to learn to protect yourself.

Click here for Lesson 3

Lesson 4:

ML/ AI/ DL: What are the similarities and differences?

What students should learn in this lesson:

Fundamentally, machine learning is a technique for using computers to predict things based on past observations. AI technology (algorithms) give computers the ability to learn without being explicitly programmed. It is a different and independent approach for utilizing computers compared to traditional programming.

Click here for Lesson 4

Lesson 5:

What is the difference between traditional code and artificial intelligence?

How does computer programming using programming languages (such as Java, Python, or Scratch) differ from machine learning applications? What are the limitations of traditional imperative programming?

Click here for Lesson 5

Lesson 6:

NLP and the GPT-3 on "What is machine learning"?

GPT-3 is a language processing model developed (the abbreviation stands for 'generative pretrained transformer') by the American non-profit organization OpenAI. It uses deep learning to create, summarize, simplify or translate texts. It is one of the first models that passed the turing test (!). It is (according to the current status of 2021) one of the most powerful A.I. models worldwide.

Click here for Lesson 6

Lesson 7:

Teachable Machine and Scratch

Train a model with a self-recorded training dataset: for generalizing a class like a cup or a sponge it is necessary to collect many different objects. And those objects need to be slightly unprecise. For example: if you make a cup dataset, you have to wave the cup slowly in front of your camera to produce different perspectives of one object. the algorithm tries to find general features that are common to all objects. Inference – the predictions/classifications a model is performing after training – works with probabilities. In most of the cases, the model will not classify with 100% certainty.

Click here for Lesson 7

Lesson 8:

ML principles unplugged

A.I. means prediction or classification performed by a model that has been trained with training data before. This Training data needs to be collected and is based on features: numbers or categories that must be measured using sensors, e.g., mass, width/height-ratio, deformability, color, surface properties and many more. The model is generalizing those many different feature values and after this training process it can predict or classify unknown data, which is called inference. It is not sufficient to take one single measurement, since no generalization or rule-extraction is possible with only one sample. Many samples are needed to form a meaningful dataset.

Click here for Lesson 8

Lesson 9:

Decision Trees or: How to convert data to trees

Decision trees are the perfect introduction to the world of machine learning algorithms. They illustrate how a machine decomposes a task, structures it, and uses optimization calculations to build the best possible model for predictions. In addition, decision trees can be interpreted very well: The finished model can be easily visualized and comprehended.

Click here for Lesson 9

Lesson 10:

Naïve Bayes Classifier or: "Never tell me the odds!"

Students learn about the concept of conditional probability using the famous psychological test question of "librarian or farmer." The surprising result opens new insights for the students about the limits of their own thinking. In the example that builds on this, the significance of a typical Corona quick test is analyzed concretely, with the students working out the technical terms of true positive/ false negative/ true negative/ false positive. The well-known formula of the Bayes theorem results in direct consequence. In the following introduction of the classifier the students are introduced to the integration of different features. This can be deepened by means of text mining or a small orange data mining project.

Click here for Lesson 10

Lesson 11:

Linear Regression

The second Part of the 'Big Three' Classification, Clustering and Regression: Data analysis of correlated data. Continuous Prediction by using inter- and extrapolations. Therefore, students must do a "trendline" inside a table calculation software like Microsoft Excel, LibreOffice Calc or Google Tables. The quality of the prediction can be estimated using the so-called correlation coefficient.

Click here for Lesson 11

Lesson 12:

Distinguish correlation and causation!

Sometimes you see connections where there are none, and that can be misleading. Here are some examples: Is there a connection between the weather and the river level? Yes, certainly, because it is to be expected that with stronger rainfalls the river levels rise! Is there a connection between the weather and the size of your shoes? Probably not!

Of course, it could be that there is an apparent correlation between your shoe size and, for example, the average annual temperature. After all, we are living in times of climate change, and as your feet grow, the annual temperature may also grow. But this is only a so-called "correlation": Correlation is a measure for relationship between variables. First of all, it says nothing about whether it is a cause-and-effect principle

Click here for Lesson 12

Lesson 13:

k-Means Clustering or: How to handle with unlabeled data?

When we must handle unlabeled data, unsupervised ml-algorithms are sometimes able to find agglomerations of datapoints and therefore can structure our data by building clusters. The k-means-clustering algorithm is a well-known example of these learning algorithms. But how can we determine how many clusters are appropriate - how to determine the 'k'-value? We can use an elbow plot and find the characteristic kink in the plotline!

Click here for Lesson 13

Lesson 14:

k-nearest neighbor or: Can we develop a kNN from scratch?

What does an implemented ML algorithm look like "under the hood"? So far, ready-made libraries have been used, and they look like the infamous "black box". In this lesson, one of the simplest ML algorithms will be implemented - here in Python, so that the well-known plotting libraries (e.g., Matplotlib) can be used. However, many other programming languages are conceivable.

Click here for Lesson 14

Lesson 15:

Support Vector Machines

The great antagonist of neural networks: Support Vector Machines were the central and most powerful algorithms during the so-called "neural winter" in the 1970s and 1980s. They are still important today. They work according to the principle of the so-called "large margin classifier": The goal of the algorithm is the broadest possible separation of the individual classes. In this process, the separation plane is called the "hyperplane".

The didactic reduction in this teaching unit is to convey the basic working principle of the support vectors, but to merely address higher concepts like the "kernel trick" as an idea without deepening them. Likewise, we will restrict ourselves to linear separable classes. Polynomial separation functions can be illustrated by a simulation but will not be deepened.

Click here for Lesson 15

Lesson 16:

Orange Data Mining Project: Price prediction of a used car

Students should independently work through the path from data preparation to data analysis to final prediction. It is important for the students to realize that despite all the highly developed algorithms, a lot of manual work is necessary in the adaptation of data and models. The students use the free software "Orange Data Mining" as a tool. "Orange" is Node-based and therefore encapsulates the complex mathematical background, allowing the students to fully focus on the data pipeline.

Click here for Lesson 16

Lesson 17:

Orange Data Mining Project: How to survive the titanic?

Students analyze an imperfect original data set. Non-perfect means that a dataset is incomplete, and some features are unusable. Thus, this scenario is close to realistic conditions: Before ML models are trained, students are forced to become familiar with the dataset from scratch. Basic assumptions about the relevance of features must be made before a meaningful selection of data can be made. The results are not always satisfactory. An average precision of the results in the range of 0.8 must be expected. But: quite plausible and surprising causal relationships can be identified again and again. For example, the probability of survival is strongly dependent on the gender or the class in which one was booked in.

Click here for Lesson 17

Lesson 18:

Summary of the complete lesson

Students should use an overall review to visualize the lesson content they have learned. Here there is the possibility to cross-link the learning contents. A general overview provides a better understanding of the interrelationships.

Click here for Lesson 18

Resources:

Click here for some useful resources for the A.I. lessons

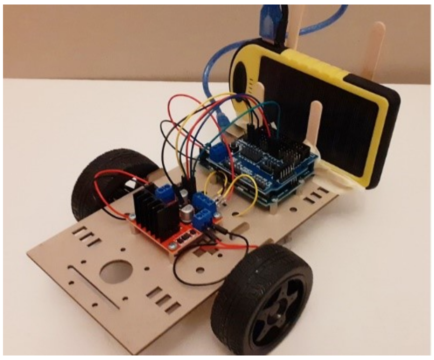
The 8 AI Projects

Project 1: control a DIY robotic car with voice commands

Organization: EDUMOTIVA

Authors: C. Papasarantou, E. Theodoropoulos, R. Alimisi, D. Alimisis

- ### Scenario from everyday life



The present scenario revolves around the idea of creating an autonomous vehicle. An autonomous vehicle is defined as a vehicle with a fully – or to a certain degree – automated driving system, able to perceive its environment and correspond to external stimuli based on data inserted by a human driver/user [1]. Regarding automation, there are six different levels extended from level 0, in which human driver fully controls the vehicle through driving, to level 5, in which the vehicle is equipped with a fully ADS (Advanced Driving System) enabling it to correspond to any physical condition and thus no human intervention (concerning driving) is needed [1]. Automation in driving has significant advantages, among others, enabling people with disabilities to drive a safer and more advanced (in comparison to electric wheelchair) means of transportation. Moreover, vehicles deprived from the physical presence of a driver have been used for the exploration of remote or/and inaccessible places (e.g., other planets, hazardous environments, deep waters etc.) or even for the execution of specific routes (e.g., driverless buses) [3] [4] [5] [6].

Regarding the future of autonomous vehicles, voice recognition is considered as one of the essential features for development and implementation [7] [9]. Currently, the most contemporary cars are equipped with voice assistant applications enabling drivers to control a number of peripherals such as music, heating, security system, navigation etc. [2]. The integration of AI has played a significant role on creating more reliable voice control systems [2] [8], but there is still work to be done on using voice as the primary method for controlling a vehicle, due to existing significant drawbacks such as instability regarding connectivity, malfunctions due to noises, and difficulties on recognizing specific languages or/and different dialects. Issues related to security (i.e., recognizing specific voices to avoid frauds) also need to be taken into consideration.

However, the implementation of voice control over driving can have many advantages. For instance, voice control could make people with motor impairments or motor disabilities capable of driving, thus having a degree of autonomy regarding their transportation. Voice commands can also add accuracy to driving (e.g., degrees of turning) and make the entire process more intuitive, while increasing the exploratory performance of remote-controlled vehicles (such as rovers).

This quite promising and challenging feature is explored through the present project. In our scenario the created vehicle will have some degree of automation, since the human driver will have the driving control through voice commands. Specifically, the driver will be able to instruct the vehicle (or DIY robotic vehicle) to move forwards and backwards, as well as to turn (right or/and left) and 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, as well as the obstructions that noises and mispronunciations can create. Moreover, the scenario can be extended by adding accuracy to voice commands (i.e., turn for 45 degrees, go straight for 100m etc.). Therefore, students can become aware of the importance and the risks of adding automation to driving through voice commands.

Learning Objectives	
Knowledge	Through this project students will be able to: ● define/explain what an autonomous vehicle is ● explain and discuss different aspects of integrating AI to a project through voice recognition and voice commands ● identify and discuss advantages and risks of implementing voice commands in driving ● explain basic programming constructs/concepts regarding the implementation of speech-to-text methods
Skills	Students will learn to: ● construct a robotic artefact and create electrical circuits as part of a robotic construction ● use programming commands coupled with AI methods to address a specific behavior to the robotic artefact ● to program a robot so that to be instructed through voice commands ● experiment with alternative solutions regarding programming and speech-to-text technologies ● reflect their ideas through programming ● exchange ideas and views in groups regarding emerging challenges
Attitudes	Students will be positive regarding: ● expressing self-confidence in applying AI programming methods related to speech-to-text technology ● setting a plan for overcoming problems/challenges ● working in groups, allocating roles and present the results of teamwork ● forming new ideas and make recommendations ● valuing the risks of using AI from an ethical point of view
Sustainable development goals	Students will be able to develop strategies that will: ● reduce inequalities by providing solutions for people with motor disabilities regarding driving a car ● promote innovation regarding navigational systems

Learning Prerequisites

No previous experience is required; however, it is highly recommended that the students are familiar with block-based coding and Arduino IDE environment. Alternatively, the Arduino IDE code for programming the DIY robotic car can be given to the students, accompanied with short comments and/or explanations. In this case, the students can only focus on making the smart application using MIT App Inventor.

Hardware & Software Prerequisites

Hardware:

Here you can find a full list with all the hardware you need for creating the robotic car. The file contains 3 pages:

- the first one contains all the components that you will need (electronics included) for the robotic car,
- the second one contains indicative materials for crafting,
- while the third one contains kits with all the needed components to make a chassis and a full kit for a robotic car[1].

Indicative suggestions regarding the quantity and the places/stores where you can find the majority of the components are also included.

Software:

For programming the robotic car: Arduino IDE (for writing and uploading the main code) https://www.arduino.cc/en/software

For warm up activities that will help students pass smoothly into Arduino IDE text-based coding: mBlock https://mblock.makeblock.com/en-us

For creating and programming the application: MIT App Inventor https://appinventor.mit.edu/

Time plan

The project is estimated to be completed in 8 hours. It is highly suggested that the training course is consisted of 4 sessions, with 2 hours per session, but based on the level of your students and the available class time, you can consider rescheduling.

1st session: Crafting and cabling the DIY Robotic Car (if you use a ready-made chassis this session may be shorter).

2nd session: Programming the DIY Robotic Car using Arduino IDE (if your students have no experience in Arduino IDE coding, shorten this session and provide ready code after some explanations),

3rd session: Integrating AI Services to our app

4th session: Creating an application that controls our car remotely using MIT App Inventor

[1] In case you choose to order a full kit, keep in mind to also order a Bluetooth module

- **Teacher's guidelines**

Guidelines | Video for Crafting

- **Worksheet for students**

Worksheet

- **Evaluation tool**

Short questionnaire for students

- **Resources**

Short demonstration of the project: https://www.youtube.com/watch?v=HNmYenOW3Ig

1. What is an autonomous vehicle, https://www.twi-global.com/technical-knowledge/faqs/what-is-an-autonomous-vehicle [accessed 8/7/2021]

2. The evolution of in-car voice control leads to win-win for all, https://www.kardome.com/blog-posts/evolution-car-voice-control [accessed 8/7/2021]

3. Remote controlled vehicles, https://en.wikipedia.org/wiki/Remote_control_vehicle [accessed 8/7/2021]

4. Mars exploration Rovers, https://mars.nasa.gov/mer/ , [accessed 8/7/2021]

5. Papadima G., Genitsaris E., Karagiotas I., Naniopoulos A. and Nalmpantis D. (2020) "Investigation of acceptance of driverless buses in the city of Trikala and optimization of the service using Conjoint Analysis", Utilities Police, Vol 62, available online: https://doi.org/10.1016/j.jup.2019.100994

6. Driverless shuttle bus trial, https://www.transport.nsw.gov.au/data-and-research/research-hub/research-hub/research-projects/driverless-shuttle-bus-trial , [accessed 8/7/2021]

7. The battle for voice recognition inside vehicles is heating up, https://techcrunch.com/2021/05/17/the-battle-for-voice-recognition-inside-vehicles-is-heating-up/ , [accessed 8/7/2021]

8. Bosch mobility solutions: Voice control: Reduced distraction, increased convenience and more safety, https://www.bosch-mobility-solutions.com/en/solutions/infotainment/voice-control/ , [accessed 8/7/2021]

9. VoicebotAI: 73% of drivers will use an In-Car Voice Assistant by 2022: Report (2019), https://voicebot.ai/2019/11/17/73-of-drivers-will-use-an-in-car-voice-assistant-by-2022-report/ , [accessed 8/7/2021]

- **Tips and Recommendations**

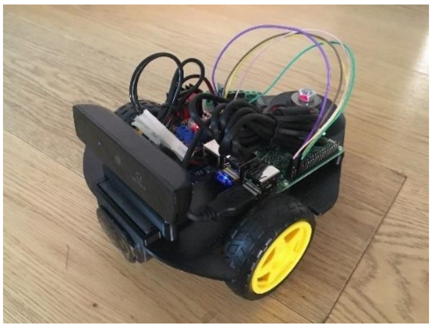
If your students have no previous experience on Arduino technology, you are advised to begin with easier projects included in this handbook, such as Project 5, Project 6 and Project 7.

Project 2: Autonomous driving vehicle recognizing traffic signs

Organization: FMD

Authors: S. Larghi, I. Gaudiello, A. Mazzucato

• Scenario from everyday life



A self-driving car, also known as an autonomous vehicle, driverless car, or robotic car, can be defined as a vehicle that is capable of sensing its environment and moving safely with little or no human input [1].

Autonomy in vehicles can be categorized in six levels, according to a system developed by the Society of Automotive Engineers (SAE) [1] from no automation (level 0) to full autonomy (level 5) where the vehicle can complete travel autonomously in any environmental conditions.

Development of self-driving cars present potential benefits but implies technological, social and ethics challenges.

Within the project, students will be able to reflect on these aspects; they will explore AI basic concepts, especially concerning computer vision, image classification and object recognition. Students will train a model that classifies street sign images using AI image classification services. They will create their own DIY vehicle capable of recognizing autonomously street signs and signals adapting its behavior using their trained model. They will also be able to experiment object recognition using a pre-trained model with their robotic car.

Learning Objectives	
Knowledge	Through this project students will be able to: • explain basically what a self-driving car is identifying different levels of autonomy • identify examples of systems using AI and identify different types of AI services • discuss integration of AI image classification and object recognition within a project • identify potential benefits of autonomous vehicles and discuss relevant challenges
Skills	Students will learn to: • build a DIY robotic vehicle • program the DIY robot vehicle movements • train an AI image classification model • program the DIY robot vehicle to adapt its behavior integrating their AI trained model • program the DIY robot vehicle integrating a pre-trained object recognition model

Attitudes	Students will be positive regarding: ● the capability of working in groups, sharing competencies and ideas ● developing problem solving attitude and strategies ● the attitude towards errors: in project-based learning, according to constructionist approach, errors are considered part of the learning process, thus enhancing students' self-confidence ● understanding and discussing ethic and social considerations regarding use of AI
Sustainable development goals	Students will be able to develop strategies that will: ● promote accessibility and inclusion ● promote technological innovation

- ## Learning Prerequisites

Coding skills and knowledge on robotics basics may be an asset, although the activity can be performed anyway.

- ## Hardware & Software Prerequisites

Hardware:

The hardware equipment needed to create the DIY robotic car is listed in the Teacher's guide [2], section 1, with assembly instructions.

To configure the Raspberry Pi at first power on, it is necessary to connect to it a mouse, keyboard and monitor.

For the creation, training and exporting of the AI model it is necessary a Windows computer or laptop with access to the internet and a webcam.

Software:

To create, train and export an AI image recognition model: https://teachablemachine.withgoogle.com/

To set-up the Raspberry Pi and program the robot vehicle:

Download the *Raspberry PI OS with desktop* from https://www.raspberrypi.com/software/operating-systems/ and download the *Raspberry Pi Imager* software for Windows from https://www.raspberrypi.com/software/ to copy the OS image on the Raspberry Pi SD, see the Teacher's guide [2], section 1.4.

To interface with the Raspberry Pi from your Windows computer or laptop, instructions to download and install VNC server on the Raspberry Pi are on the Teacher's guide [2], section 1.4; to download and install VNC viewer on your Windows computer or laptop: https://www.realvnc.com/download/file/viewer.files/VNC-Viewer-6.21.920-Windows.exe.

• Time plan

Estimation for total time needed for the project: 8 hours

The project can be organised in four working sessions:

- session 1: discussion of autonomous vehicles and AI concepts, image classification and object recognition and how to integrate them within the project – 2 hours [use student worksheet for session 1]
- session 2: building of the robot vehicle, set up and programming - 2 hours
- session 3: training of image classification model with Google Teachable machine, programming the vehicle integrating the AI trained model and testing - 2 hours
- session 4: integrating pre-trained object recognition model and discussing the difference with previous implementation; discussion on results, benefits and challenges; conclusions - 2 hours

• Teacher's guidelines

Guidelines

• Worksheet for students

Student worksheet for session 1: contains questions to encourage discussion on autonomous vehicles, what they are, how they work, AI concepts, computer vision/image classification/object detection

Worksheet

• Evaluation tool

Short questionnaire for students

• Resources

Short demonstration of the project: https://www.youtube.com/watch?v=aStlKmkE8UQ

To become more familiar with AI basics
https://www.sas.com/en_us/insights/articles/analytics/five-ai-technologies.html [3]

For information on OpenCV (Open Source Computer Vision Library): https://opencv.org

For information on TensorFlow: https://www.tensorflow.org/

Examples of TensorFlow Lite Python image classification with Raspberry Pi Camera: https://github.com/tensorflow/examples/tree/master/lite/examples/image_classification/raspberry_pi.

Examples of OpenCV use: https://github.com/EdjeElectronics/TensorFlow-Lite-Object-Detection-on-Android-and-Raspberry-Pi/blob/master/Raspberry_Pi_Guide.md.

References:

[1] Self-driving car - Wikipedia

[2] Autonomous driving vehicle recognizing traffic signs - Teacher's guide

[3] https://www.sas.com/en_us/insights/articles/analytics/five-ai-technologies.html

[4] https://opencv.org

[5] https://www.tensorflow.org/

[6]https://github.com/tensorflow/examples/tree/master/lite/examples/image_classification/raspberry_pi

[7] https://github.com/EdjeElectronics/TensorFlow-Lite-Object-Detection-on-Android-and-Raspberry-Pi/blob/master/Raspberry_Pi_Guide.md

• Tips and Recommendations

If your students are not familiar with raspberry pi technology or/and with python programming language, you might need to foresee some extra hours to smoothly introduce them to the aforementioned topics.

If a 3d printer is available, you can encourage your students to design a 3D model of the chassis.

To smoothly introduce your students to AI and ML concepts, you can also use the material included on the first lessons of Project 0.

Project 3: Virtual Secretary office chatbot

Organization: AIJU

Authors: A. Sánchez and J. C. Sola

- **Scenario from everyday life**

A **Chatbot** is a conversational assistant that can connect to various platforms to communicate with real people using natural language. This can be done through sound (voice) or text. Some famous examples of Chatbot or conversational assistant are Alexa (developed by Amazon), Siri (developed by Apple), Cortanta (developed by Microsoft). All of them are AIs that can communicate with real people and in this text, we will call them Chatbots.

These Chatbots appeared in the 1960s trying to simulate conversations with real people by providing automatic responses that were previously defined by experts (e.g., software developers and linguists), who have to ensure that Chatbots work well.

To make a good conversation between the Chatbot and a human being, you have to make simple sentences that are easily understandable. This is often difficult and is a challenge that both private companies and freelancers as well as common people have to solve. To understand the sentences, Chatbots use probabilistic patterns that allow them to give an appropriate answer, which has been designed in advance. With these probabilistic patterns, Chatbots can have more or less logical conversations.

Thanks to chatbots, repetitive and time-consuming tasks related to bureaucracy, or problems in customer service, due to lack of human assistants leading to long waiting hours and negative feelings such as dissatisfaction and frustration, can be overcome.

To make this happen, there are different levels of chatbots, which are explained below:

❖ **Level 1: Message sending Chatbot**:

This is the most basic level of the Chatbot, where the only function is to send messages from phones, messaging apps or Android and iOS devices with a basic configuration.

❖ **Level 2: FAQ Chatbots**:

They are currently the most widely used. These types of bots allow simple questions with simple answers and can even hold simple conversations between a real person and a chatbot. The chatbot of this project belongs to this level.

❖ **Level 3: Contextual Chatbots**:

Chatbots of this type are capable of holding a conversation between a real person and a Chatbot but in this case, the Chatbot can differentiate the context of the conversation and the Chatbot can answer unexpected questions.

❖ **Level 4: Custom Assistants**:

These Chatbots are able to be proactive when a conversation is held between a real person and a Chatbot, and are also able to improve themselves in future responses.

- **Level 5: Autonomous Chatbots**:

They are the latest evolution of chatbots, and would be able to handle complex stock market transactions, for example, or lead companies by making logical decisions. This technology is not yet available, but some experts believe that such chatbots will soon become a reality.

Learning Objectives	
Knowledge	Students should: • understand how chatbots work and what levels of chatbots exist. • be familiar with some platforms on which they can develop a chatbot. • know how to program a chatbot with JSON files.
Skills	Students should know: • what the intents, entities and actions of a chatbot are. • how to develop a chatbot on Telegram and how to make responses for Telegram. • how to train the chatbot on the platform in DialogFlow when it gets an error caused by a question that the bot cannot understand. • how to program a chatbot using JSON files in Java Script.
Attitudes	Students with a positive attitude are able to develop a simple chatbot and learn how artificial intelligence can benefit this discipline.
Sustainable development goals	This project contributes to the democratisation of artificial intelligence and technology, empowering young people to learn the new language of the future, the programming language, and immerse themselves in the 4.0 revolution.

Learning Prerequisites

Students do not need to have previous experience in using the DialogFlow platform or other similar platforms, but it is highly recommended that students know some programming language. The programming language does not matter. If they do not know any programming language, they should at least have strong logical thinking skills as well as strong computer skills and computer knowledge.

Hardware & Software Prerequisites

Software:
To develop the chatbot, students need a computer and a google account to program the chatbot and they also need a smartphone with the Telegram app to deploy the chatbot.

The chatbot will be deployed in DialogFLow and will be able to access this web page: https://dialogflow.cloud.google.com/

- ## Time plan

The project can be divided into three parts:

a. The first part is to become familiar with the **DialogFlow** platform. This means that they should learn how to create a chatbot, what are the parts of a chatbot and how they could develop this chatbot in DialogFlow.

b. The second part is the longest one. In this part students have to develop their own simple chatbot. They have to make a chatbot that tells jokes, talks about their football teams, gives some tips and suggests places to travel using links and images.

c. The third part is to deploy the chatbot in Telegram and learn about some applications where students could deploy other chatbots. The programming part with java script and JSON files should also be introduced.

The project needs 8 hours to be completed and will be divided into 4 sessions of 2 hours:

1st session: The first part will be done.

2nd session: The first part of the second part will be done.

3rd session: The second part of the second part will be done.

4th session: The third part will be done.

- ## Teacher's guidelines

Guidelines

- ## Worksheet for students

Students have to follow both the DialogFlow handbook and the document explaining how the chatbot called "Roque" has been developed and if students succeed in making a similar chatbot, students are considered to have achieved the objective.

Worksheet

- ## Evaluation tool

Short questionnaire for students

- ## Tips and Recommendations

In case you choose to install DialogFlow software in your local/native language (e.g. Greek), keep in mind that there might be slight differences on the embedded menus.

Project 4: Face recognition

Organization: AIJU

Authors: A. Sánchez and J. C. Sola

- **Scenario from everyday life**

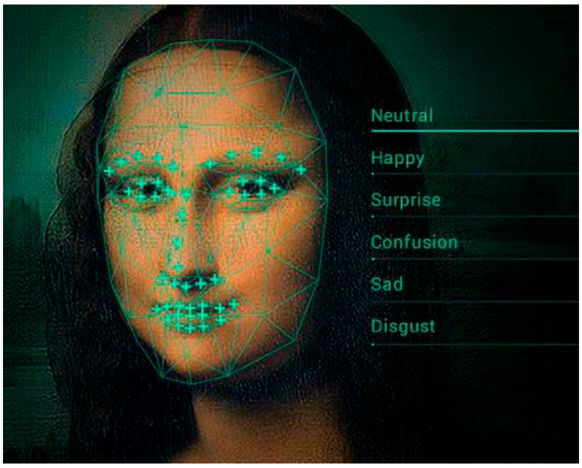


Figure 1: Recognition of the Emotion of the Mona Lisa Painting - https://blog.realeyesit.com/mona-lisas-smile-in-the-mind

For **Image Recognition**, one of the most widely used technologies is **Deep Learning**, which, in addition to allowing image recognition, enables natural language analysis and anticipates problems by extracting behavioral patterns. For example, through image recognition, Deep Learning is able to detect all objects in a given image. In this direction, one of the most important implementations is the analysis of CT scans and X-rays of patients with Alzheimer's disease, where Deep Learning analysis searches for anomalies that can predict the development of the disease. Moreover, through Artificial Vision, (originated by Deep Learning, and accompanied by neural processing), a number of therapeutic and brain stimulating activities such as puzzles, can be enriched with devices designed for assisting such patients towards this process (i.e., help them to fit a piece in a puzzle, advise them for possible movements etc.).

In short, Machine Vision is a field of Artificial Intelligence trained to interpret and understand the real world. Machines can accurately identify and locate objects and then react to what they "see" using digital images from cameras, videos and models, as well as being complemented by neural processing, enabling real-time text translation.

Therefore, thanks to **Image Recognition**, we can develop Facial Recognition applications.

Face Recognition is a subfield of Computer Vision that allows machines to recognize or/and identify human faces from digital content such as photos and videos in real-time. Algorithms are used to detect a human face and even to identify a person from their biometrical characteristics. Face recognition is widely used in our everyday life, from tagging photos in social media, and locking or unlocking our smart devices, to proceeding to financial transactions, or optimizing photos, for public security like airports and frontiers borders.

Due to Face Recognition, we can also apply **Emotion Recognition**, by collecting data on how people are communicating in verbal or non-verbal ways, so as to understand their mood or attitude. To do this, the development of emotion analysis software requires large amounts of labelled emotion data. Emotion data comes from video cameras that capture facial expressions and microphones that collect data on voice tones. This data is fed into machine learning algorithms, which learn to recognize expressions, tones and other features that correlate with specific emotions. Current emotion recognition technology generally classifies emotions as: Anger, Contempt, Confusion, Disgust, Fear, Frustration, Joy, Sadness and Surprise.

Therefore, in this Artificial Intelligence project, the student will be able to work directly with an image bank, where the code will identify those people who are happy and those who have other types of feeling.

Learning Objectives	
Knowledge	Students should: ● understand how Image Recognition and Facial Recognition work. ● be familiar with some platforms on which they can develop different Artificial Intelligence applications.
Skills	Students will develop their computational skills, such as logical thinking, creativity, and, of course, teamwork.
Attitudes	Students with a positive attitude are able to develop applications that incorporate Artificial Intelligence, at a more advanced level, and learn the benefits of Image Recognition, and consequently, Facial Recognition and Emotion Analysis.
Sustainable development goals	This project contributes to the democratisation of Artificial Intelligence and technology, empowering young people to learn the new language of the future, the programming language, and immerse themselves in the 4.0 revolution.

• Learning Prerequisites

As prerequisites to the development of any Artificial Intelligence application, it is necessary to have the basic notions of programming, such as variables, functions, etc. In short, computational thinking allows them to advance by learning AI.

It is also highly recommended to know the Python programming language, which is currently the most widely used language.

• Hardware & Software Prerequisites

a. Basic solution

Software: To develop the Emotion Recognition application, students need a computer and they need to use the mBlock Software: https://ide.mblock.cc/

Hardware: Webcam.

b. Advanced solution

Software: To develop the Facial Recognition app, students need a computer in which they will download the Anaconda software: Go to https://www.anaconda.com/ and click on Products → Individual Edition

Hardware: Webcam.

- ## Time plan

The project will take approximately 10 hours to be completed and should be divided into five 2-hour sessions, where the fourth session could be more complex:

1) The first part of the project consists of the development of a program using communication blocks and cognitive libraries.

2) The second part is to study in-depth how the libraries that are used when we make use of block programming work. To this end, it is necessary to learn and know the Anaconda platform, since it is a tool thought to carry out different Artificial Intelligence Projects, and it is currently used by professionals.

3) The third part would be the theoretical part of Image Recognition, Facial Recognition and Sentiment Analysis, where, combining the different technologies, you can get important data about people.

4) The fourth part is the longest because it is the part where students have to develop their Facial Recognition application. They can develop applications where it identifies their classmates, recognize a person's emotions, etc.

5) The fifth part will be to present their projects to the rest of the classmates, where all classmates will provide feedback and improve those sections as appropriate.

- ## Teacher's guidelines

Guidelines

- ## Worksheet for students

Worksheet

- ## Evaluation tool

Short questionnaire for students

- ## Tips and Recommendations

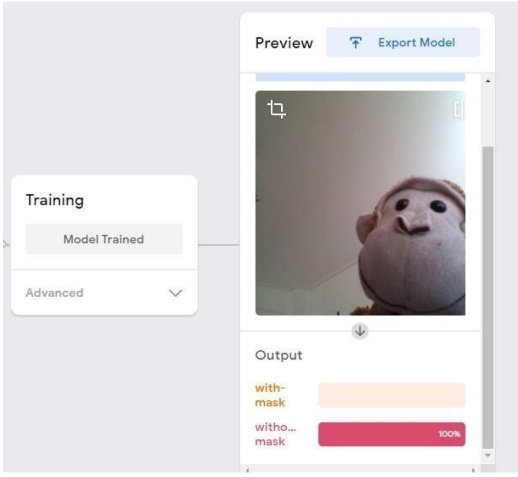
To smoothly introduce your students to AI, ML and DL concepts, you can also use the material included in some of the lessons included in Project 0, such as lesson 4.

Project 5: Open Sesame

Organization: EDUMOTIVA

Authors: G. Lascari, D. Alimisis

- ### Scenario from everyday life



Computer Vision is a field of artificial intelligence that trains computers to interpret and understand the visual world, using deep learning and neural networks. By identifying and classifying objects, machines and mobile devices can interact with the physical world. For example, self-driving cars can make sense of their surroundings, robotics arms can detect damaged components, visually impaired people are able to “see” pictures on their mobiles, endangered species can be monitored, diseases can be diagnosed from medical images, etc. Computer vision possibilities and applications are one of the most promising fields of Artificial Intelligence.

Face recognition is a subfield of Computer Vision that allows machines to recognize or/and identify human faces from digital content as photos, videos or in real-time. Algorithms can be used to detect a human face and even to identify a person from his biometrical characteristics. Face recognition is widely used in our everyday life, for example in tagging photos in social media platforms, locking and unlocking our mobile devices or smart doors, allowing us to proceed to financial transactions, optimizing our personal photos, for public security like airports and frontiers borders.

Amid the Covid-19 pandemic which has caused a global health crisis, facial recognition could be used as a tool for public health security, by detecting people with or without masks in spaces where wearing a mask is mandatory.

- How could we create a mask-detection application based on an ML model?
- How accurate could this model be?
- How can we ensure not to introduce biased data in our model?
- Could this model raise ethical issues?

Let’s find how by creating an automated smart door system based on face recognition to ensure that only students wearing covid-19 will enter at school.

Learning Objectives	
Knowledge	After the end of this activity students will be able to: ● understand the Supervised Machine Learning as a subset of Artificial Intelligence ● understand the need of collecting not only quantity but also quality data ● realize the impact of the data on the accuracy of an ML model ● build, test and evaluate an ML model using the Google Teachable Machine ● understand the biases and the ethical issues related to Artificial Intelligence and ML technologies ● understand the basic components of Arduino boards ● learn how servo motors work and how to control servo motors using Arduino ● learn how to program an Arduino board using basic Pictoblox block commands ● design a program on Pictoblox using the Arduino and the Machine Learning extensions ● build an automatic door opening and closing using a servo motor and an ML mask recognition model ● comprehend the potential threat for human rights raised by the use of AI
Skills	**Critical Thinking:** Students develop their critical thinking, innovation and creativity by trying to implement a motorized smart door mechanism based on the results of their trained Machine Learning Model. **Problem-solving/ Computational thinking:** Students define how to create, train and optimize their ML model, find the most appropriate way to set up, program and control the servo motor as the mechanical part of the artefact, make decisions and find solutions on how to combine their ML model and the Arduino microcontroller within the Pictoblocx environment to get the appropriate result.
Attitudes	Students develop positive attitudes such as taking initiative, learning how to interact with one another and value each other's opinions. They plan and manage time for doing all activities effectively, participate actively and successfully collaborate. Within those activities, they develop a sense of responsibility as they are asked to suggest applicable and realistic solutions. Students realize the need of using technology for good, taking into account inclusive solutions while simultaneously raising awareness on the ethical issues of those emerging technologies.

Sustainable development goals	**SDG goal 3:** Good Health and Well-Being. Face masks are recommended as part of personal protective equipment and as a public health measure to prevent the spread of coronavirus disease 2019 (Covid-19) pandemic. The Covid-19 pandemic has led to a dramatic loss of human life worldwide and to an unprecedented crisis in public health. More than ever, global and national policies must be able to face such pandemic crises and ensure healthy lives and well-being at all ages. **SDG goal 16:** Peace and Justice Strong Institutions. Face recognition technology can be used to detect, supervise and control humans and therefore is a potential threat to basic human rights like the right to privacy, freedom of movement and residence and the right to assemble. SDG goal 16, ensures public access to information and protect fundamental freedoms, in accordance with national legislation and international agreements.

• Learning Prerequisites

No prerequisites needed

• Hardware & Software Prerequisites

- Computers equipped with a web camera
- Internet connection
- An Arduino board
- Micro Servo Motor with Accessories
- Male to Female Jumper Cable
- Pictoblox software

• Time plan

Estimation for total time needed: 3- 4 didactic hours

• Teacher's guidelines

project-based methodology, pedagogical tips and complete technical solution for teachers

Guidelines Videos

• Worksheet for students

Worksheet to support students implement the project. Solutions are not directly provided in order to give space for students to investigate, take initiatives and use their imagination and creativity.

Worksheet

- ## Evaluation tool

Short questionnaire for students

Pictoblox assessment tool – Click here

Machine Learning assessment tool – Click here

- ## Resources

Introduction to Machine Learning basics and AI:

Videos

- Introduction to Artificial Intelligence in the classroom – Code Week Learning Bits
- "AI: What is Machine Learning?"
- "How AI Works"
- "Computer Vision"

Educational Games

- AI for Oceans Hour of Code
- Minecraft Hour of Code: AI for Good

SDGs:

- "COVID-19 Is More Than a Health Crisis"
- "The Global Action Plan for Healthy Lives and Well-being for All"

- ## Tips and Recommendations

If there are restrictions concerning sensitive data (i.e., uploading and storing in public domains images of students' faces), you can consider slightly changing the scenario of the project, or encourage students to use a toy (such as a teddy bear) for the training and testing process.

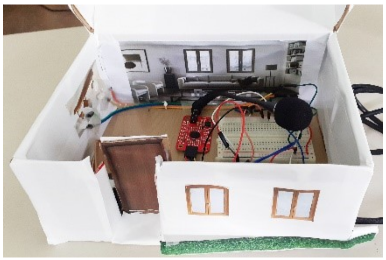
If your students are familiar with the Scratch block-based programming environment, you can implement Lesson 7 of Project 0, to smoothly introduce them to the Teachable machine.

Project 6: Voice recognition with Arduino board

Organization: FMD

Authors: M.T. Sorrenti, I. Gaudiello, V. Gelsomini

- ### Scenario from everyday life



Voice-recognition based technologies offer many advantages for everyday life tasks, in particular for people with disabilities.

Home automation is an application field which does benefit from this kind of technology, but it is not the only one. Road safety, assistance to persons with disabilities and game design are also fields where voice recognition can be very useful.

Some examples are solutions for visual impairments aids; or bike-riding enhanced systems in which a set of voice-controlled turn signals are activated simply by saying which direction you are heading towards

Learning Objectives	
Knowledge	Through this project students will be able to: ● explain what a voice recognition system is; ● explain and discuss different aspects of integrating AI in a project through voice recognition and voice commands; ● identify and discuss advantages of implementing voice commands in domotic; ● define basic programming constructs/concepts regarding the implementation of voice commands.
Skills	Students will learn to: ● transform ideas in programming solutions ● build a system that allows to control electrical devices by means of an AI based device using voice commands; ● use programming commands to address a specific behavior to the voice recognition artefact; ● experiment with a variety of concrete applications of voice recognition; ● exchange ideas and views in groups with regards to emerging challenges in the field of voice recognition.

Attitudes	Through this project, the following attitudes will be encouraged: ● passion for technology and innovation; ● self-confidence in applying AI programming methods ● disposition for overcoming problems/challenges thanks to planification; ● collaboration for teamwork; ● open-mindedness towards new ideas ● consciousness about AI related risk and ethical issues
Sustainable development goals	Students will be able to develop strategies that will: ● reduce inequalities by providing solutions for people with motor disabilities (e.g. light systems, audible warning, motor control - for example to lift a shutter - , etc.). ● implement inclusive technologies (motor impairment, etc.).

• Learning Prerequisites

In order to achieve the identified objectives with due awareness, it is recommended for students to know:

- the basic operating principles of a microcontroller
- the main parts of the Arduino board and its development environment
- the fundamental constructs of programming

• Hardware & Software Prerequisites

The hardware components needed for this project are:

- Arduino Uno shield (or other shields, e.g.Arduino Nano, Arduino Mega, etc.)
- Elechouse V3 Voice Recognition module or similar and a Microphone
- Led (generic)
- Resistor 220 Ω
- A breadboard and some cables

For an eventual expansion of the project, you also may need:

- a buzzer
- a servomotor

The app and online services needed for this project are:

- Arduino IDE
- Library VoiceRecognition-Master

The device has to be connected to:

- a computer, via USB cable
- a Wi-Fi network, via SSID (network name) and password

The programming environment is Cross-platform. This platform works on Windows, Macintosh and Linux, it is entirely open source and is supported by a community that shares knowledge, examples and applications; moreover, card’s cost is affordable.

- ## Time plan

The total estimated time for the implementation of the project is 5 hours into the following sessions:

- definition of the characteristics of the V3 Voice Recognition module, assembly of the hardware part of the project, installation of libraries and module training
- project testing and questionnaire
- variants with buzzer and servomotor are suggested to students, providing triggering questions, “half-baked” solutions, and tips.

- ## Teacher’s guidelines

The project encourages the implementation of new teaching / learning approaches based on active pedagogy - according to which learning involves the active construction of meaning by the learner - and encourages an expansion of curricular paths for the development and strengthening of soft and hard skills in the domain of AI education.
The teaching methodology used is that of inquiry-based learning teaching. Within this frame, the laboratory is intended not only as a physical space but mainly as a mental place; in it we not only teach and / or learn, but we "do", we experiment operationally, and we are conceptually confronted with the problematic nature of the scientific processes and with a meaningful use of technology. A complete technical solution for teachers is reported in the students’ worksheet.

Guidelines

- ## Worksheet for students

Worksheet

- ## Evaluation tool

Short questionnaire for students

- ## Resources

Short demonstration of the project: https://www.youtube.com/watch?v=c77-1ieV9xQ

Resources to help students understand AI & ML concepts used in this project:

Introduction to Machine Learning basics and AI:

- “AI: What is Machine Learning?”
- “How AI Works”

Other resources are listed in the student worksheets

- ## Tips and Recommendations

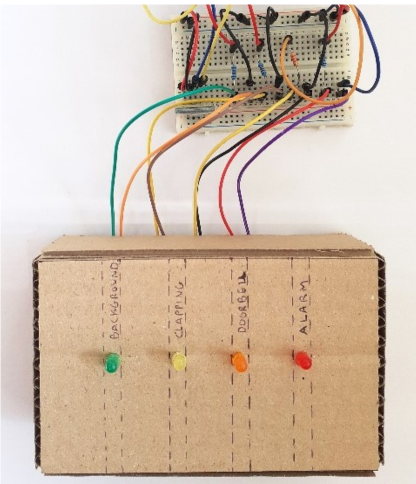
Keep in mind that ambient noise can cause difficulties during the training process.

Project 7: Device that turns sounds to visual signs

Organization: EDUMOTIVA

Authors: C. Papasarantou, E. Theodoropoulos, R. Alimisi, D. Alimisis

- ### Scenario from everyday life



The World Health Organization estimates that over 5% of the population (equivalent to roughly 390.000.000 people) has significant hearing loss [1]. Hearing loss is a condition that can happen not only at birth but at any age [2]. As people with significant hearing loss can be considered not only the deaf people but also those with hard of hearing or hearing-deterioration. Based on these facts, it should be a wider understanding that this group of people have – among others – different needs regarding accommodation [1] [3]. However, these needs are not reflected in the current state of housing design, since there is a lack of knowledge on how hearing loss "can affect a person's daily life, even at home" [1].

Luckily, today there are many strategies – including technology upgrades – that can be adopted in order to improve a home and adapt it to the needs of this group of people, as well as the individual preferences (since the experience of hearing loss and consequently the emerging needs can vastly vary). Some technologically based paradigms include specialized smoke alarms or security systems/alarms, flashing lights or vibrating in case of emergency, lights that are activated when a doorbell rings, outdoor motion sensor lights activated by the presence of intruders, wake-up alarms equipped with louder sounds or vibration etc. [1] [4]. In general, deaf people rely more on visual information, therefore strategies that engage them in a visual way can be considered as more useful and successful.

With these as a solid base, the present project is oriented towards the creation of an electronic device that will turn significant sound information that can occur at a house, to visual signs. For the realization of this scenario the use of Arduino technology, combined with an application created with MIT App inventor, is proposed. The application will be able to detect and classify sounds according to their significance (i.e., sound of a flat-mate walking in the house = less significant, sound of ringing doorbell = more significant etc.). Based on the incoming sound, the application will emit visual signals through an electronic device, designed for this purpose. The core mechanism of this device will be an Arduino board, equipped with Bluetooth module and LED lights (of different color) that will turn on or flash/blink, according to the importance of the incoming sound, while the design of the device can be freely decided/approached by the creator (e.g., creating a paper model for embedding the mechanism, designing and printing a 3d model etc.).

Learning Objectives	
Knowledge	Through this project students will be able to: • explain and discuss different aspects of using AI for helping a specific group of people • explain basic concepts regarding the audio classification process • identify and discuss advantages and risks of audio classification problem • explain basic concepts regarding turning an audible information to a visual one
Skills	Students will learn to: • construct an electronic artefact and create electrical circuits as part of a programmable electronic device • use programming commands coupled with AI methods to address a specific behavior to an electronic device • classifying different sounds based on specific criteria • train a model to classify different sounds • reflect their ideas through programming • exchange ideas and views in groups regarding emerging challenges
Attitudes	Students will be positive regarding: • expressing self-confidence in applying AI programming methods related to audio classification technology • setting a plan for overcoming problems/challenges • working in groups, allocating roles and present the results of teamwork • forming new ideas and make recommendations • valuing the risks of using AI from an ethical point of view
Sustainable development goals	Students will be able to develop strategies that will: • reduce inequalities by providing solutions for people with hearing disabilities regarding their daily life in a domestic environment • promote innovation regarding domestic systems

- ## Learning Prerequisites

No previous experience is required; however, it is highly recommended that the students are familiar with block-based coding and Arduino IDE. Alternatively, the Arduino IDE code for programming the Arduino-based electronic device can be given to the students, accompanied with some short comments and/or explanations. In this case, the students can only focus on audio classification processes, as well as on making the application using MIT App Inventor.

- ## Hardware & Software Prerequisites

Hardware:
For the needs of this project, you will need:
- An Arduino board
- A breadboard
- LED lights of different color
- some resistors of 220ohm
- A Bluetooth module (HC-05 or HC-06)
- Jumpers (M-M, F-M, F-F)
- cardboards, colored papers, colored markers, glue, scissors, and any other simple material that can be used for crafting and is suitable for your students' age

Software:
For programming the electronic device: Arduino IDE (for writing and uploading the main code) https://www.arduino.cc/en/software
For warm up activities that will help students pass smoothly into Arduino IDE text-based coding: mBlock https://mblock.makeblock.com/en-us
TinkerCAD circuits: https://www.tinkercad.com/
or Pictoblox https://thestempedia.com/product/pictoblox/
For creating and programming the application: MIT App Inventor https://appinventor.mit.edu/
For audio classification: Personal Audio Classifier (PAC) training environment
https://c1.appinventor.mit.edu/

- ## Time plan

The project is estimated to be completed in 6 hours. It is highly suggested that the training course consists of 3 sessions, with 2 hours per session, but based on the level of your students and the available class time, you can consider rescheduling.

1st session: Creating the circuit and programming the electronic device. Making a number of warm up activities to introduce your students to coding is highly recommended.

2nd session: Creating a model to embed the circuit of your device, thus turning it into an artefact (crafting process). Training a model for classifying different audios.

3rd session: Creating an application, in which AI Services are integrated, in order to enable your electronic device to turn the audible information to visual one

- ## Teacher's guidelines

Guidelines **PowerPoint presentation with videos**

- ## Worksheet for students

Worksheet

- ## Evaluation tool

Short questionnaire for students

- ## Resources

Short demonstration of the project: https://www.youtube.com/watch?v=RXt03hPiQSw

Resources regarding hearing loss:

[1] https://www.yourathometeam.com/deaf-or-hard-of-hearing-home-improvements/

[2] https://www.chchearing.org/facts-about-hearing-loss

[3] https://www.hearinglikeme.com/accessible-home-for-deaf-and-hard-of-hearing-people/

[4] https://www.hearsoundly.com/guides/vibrating-alarm-clocks-deaf-hard-of-hearing

- ## Tips and Recommendations

To smoothly introduce and familiarize your students to Arduino IDE code, you can consider using the TinkerCAD circuits environment.

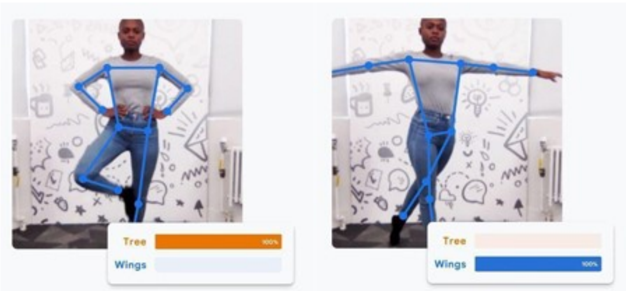
This project can be used as a smooth introduction to Project 1.

Project 8: Health AI application: poses recognition in rehabilitation

Organization: FMD

Authors: C. Borgogno, I. Gaudiello

- ### Scenario from everyday life



Body movement detection is a challenging field in AI.

Automatized detection systems can be very useful in rehabilitation for example.

In order to guide students' reflection about poses recognition in everyday life, teachers can propose some triggering questions, such as: can you think of an effective ethical app supporting patients during rehabilitation?

Which hardware would you use and how? (for ex. a pc camera positioned at a specific place). Which software would you use and how? (for ex. AI game-based software, trained with video-sequences of body movements, and offering an "activities menu"; the software can have different characteristics which need to be detailed: response time for pose recognition, etc.). Are there any ethical issues to discuss? (for ex. there is no difference in human perception).

Learning Objectives	
Knowledge	Through this project students will be able to: ● training model of neural networks; ● gamification techniques to encourage user engagement ● vectorial graphics; ● notions of rehabilitation.
Skills	Students will learn: ● coding skills ● integrating an AI model into an application;
Attitudes	Students will be positive regarding: ● interest in patients' well-being
Sustainable development goals	Students will learn how to design an inclusive and accessible app based on visual and sound signals to detect body schema during rehabilitation

- ### Learning Prerequisites

Students must know visual block coding or instruction coding for K-12 or javascript basics with P5JS for the higher secondary schools

- ## Hardware & Software Prerequisites

Equipment needed for this project:

- gymnastics mat, athletic wear and shoes to practice the gym exercises;
- High resolution camera (or a camera allowing to detect body movements;
- internet connection to use the training model stored in Google cloud;
- software to develop the application: Scratch or Javascript (for Chrome browser).

- ## Time plan

The activity takes 10 hours:

- 1 hour to learn how to use the Teacheable machine
- 1 hour to release the first game application
- 1 hour to analyse the rehabilitation exercises
- 3 hours to develop the structure of the exercise with gamification reinforcement
- 1 hour to test the entire training process with real patients

- ## Teacher's guidelines

The teacher's guide contains a description of the didactic scenario to help teachers manage the class during this activity: after a starting phase where students get acquainted with the main concepts of IA techniques for rehabilitation games, teams of the class will work on different rehabilitation cases. In the final part of the project, the different solutions will be reassembled in a unique project.

Guidelines

- ## Worksheet for students

The worksheet is meant to guide students' activities through the whole project. The three main questions addressed by the project are

A. "Could a computer evaluation improve rehabilitation success ?" Under this respect, students must know the principle of supervised and unsupervised learning models, as a prerequisite. An external expert introduces muscles and skeleton function.

B. "Could gamification help the patients in rehabilitation?"

   Under this respect, students experiment poses detection through a game based on simple commands (pong or pacman for example) where the correct instruction increases the player's score.

C. "Is the posis detection mature for rehabilitation?"

   Under this respect, students will create a rehabilitation path where the patient is provided with an exercise and the system analyses the execution.

Worksheet

Evaluation tool

Defining a technique to evaluate possible bias in the final application is crucial.

To this aim, a short questionnaire concerning the three phases of supervised learning (training, importance of model and its use in prediction) will be proposed.

It is also important to share the AI solution with the community, in order to examine useful feedback with relation to the different exercises and eventual improvements.

Short questionnaire for students

Resources

Introduction examples: The teacheable machine learning with pose project.

Introduction to Machine Learning basics and AI:

- Introduction to Artificial Intelligence in the classroom – Code Week Learning Bits
- "AI: What is Machine Learning?"
- "How AI Works"
- Tables of Plymouth Marjon University Edublogs: examples of most common rehabilitation exercises
- A case of studies: The head tilt with teacheable machine
- The gamification elements in changement process

AI projects evaluation

In this section, the results of the evaluation of each one of the AI projects are gathered. The evaluation of each project was made by both teachers and students through questionnaires that were provided in an online form. Students' questionnaire was consisted by 7 multiple choice questions (plus two fields asking for their age and the name of the school they are attending), while teacher's questionnaire contained both multiple choice and open-ended questions, as well as some fields for uploading audiovisual material (images and/or videos captured during the piloting process).

The questions/items contained in student's questionnaire were focusing on collecting data and recording aspects related to the likeability and difficulty of each project (i.e., how much did students like each one of the piloted projects and how difficult they were) as well as on aspects related to the gained knowledge and possibly future applicability (e.g., to what extent they understood what AI and ML is, if they feel confident to make similar projects in the future, if they were motivated to search more about AI etc.). Moreover, they were asked to evaluate the provided material aiming to assist the implementation of each project (i.e., students' worksheets).

Teacher's questionnaires contained questions recording the piloting process (i.e., period of implementation, number and age of students that were involved), items reflecting their own experience regarding the content and the learning value of each project as well as questions documenting the difficulties that might be faced and thoughts about future improvements.

Apart from the evaluation forms (i.e., questionnaires) feedback was also received through thorough discussion that took place during the C3 training with some of the teachers who implement the projects. During these days, teachers shared their experiences of the implementation by reporting the difficulties they (and their students) confronted, the ways they tackled problems that emerged, the valuable aspects, the time they needed for each part of the process, the valuable aspects of each project, as well as ideas on how these projects can be enriched and/or improved.

The following projects were piloted: Project 1 (Control a DIY robotic car with voice commands), Project 2 (Autonomous driving vehicle recognizing traffic signs), Project 3 (Virtual Secretary Office Chatbot), Project 4 (Face Recognition), Project 5 (Open Sesame), Project 6 (Voice Recognition with Arduino board) and Project 7 (Device that turns audio to visual signs). Apart from these, Project 0 (i.e., introductory lessons on AI and ML) was also piloted in one of the partner schools. All projects were implemented by at least 30 students. In particular, Project 1 was implemented by 37 students, Project 2 by 57, Project 3 by 30, Project 4 by 51, Project 5 by 31, Project 6 by 38, Project 7 by 30 and Project 0 by 40; a fact which can lead to some fruitful outcomes regarding the quality and the usefulness of these projects towards introducing AI to school education[2].

[2] According to teachers' feedback, in some of the projects there were more students who participated, but not all of them did gave feedback through the provided online evaluation form.

Project 1 (Control a DIY robotic car with voice commands) evaluation

This project was implemented by 37 students, ages from 15 to 17 years old, in two different countries (i.e., Greece and Spain) (*Figure 2*)[3]. This project revolves around the creation of a robotic car (an Arduino-based one) as well as the creation of an application that will allow user/creator to control it (the robotic car) by giving voice commands. 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 (with half-baked solutions, circuit maps and tips) would be provided in each one of these teams, while teachers would move around, assisting them or giving tips whenever it was necessary. Due to Covid19 restrictions, the implementation was made in teams of 2 or 3 students.

Figure 2: Piloting project 1 in Spain and Greece: Images from the assembling process and the programming of the application

The students who implement this project, did not have any previous experience on working with Arduino technology, but they have some experience on programming. Therefore, the teachers had to do introductory lessons not only on Arduino technology but also on Arduino IDE programming environment. They also did some introductory courses to familiarize students with related to 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 2*).

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 implementation. 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

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[3] Video presenting teachers' and students' experiences of Project 1: https://www.youtube.com/watch?v=HZkyWBCu2cg

like this project", since the majority of them answered 4, getting a mean average equal to 4,08 (*Table 2*).

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

Table 2: Results from students' questionnaires regarding how much they liked the project and how difficult they think it was

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 lying 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, the results indicate that the majority of students feel – at least to a certain extent – confident with these concepts (*Table 3*). In particular, and regarding explaining what AI is, there were 10 students who replied 'Yes' and 25 'A bit'. Regarding 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 implementation 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, 24 students declared feeling 'A bit" confident and 10 of them replied 'Yes'.

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

Table 3: Results from students' questionnaires reflecting their attitude towards AI and ML

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 4*). Regarding motivation on learning more about AI, 17 students declared that they have been definitely motivated, 16 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.

	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
This project has motivated me to learn more about AI	**17**	16	3	1

Table 4: Results from students' questionnaires concerning gained knowledge and motivation

Regarding the produced material aiming to assist both teachers and students toward the implementation of this project (i.e., teacher's guidelines and students' worksheets), the results are positive. Teachers strongly agreed with the statement regarding the content of teacher's guidelines, and if it was helpful towards organizing and planning this project. Also, they agreed with the statement regarding the usefulness of students' worksheets, which is also reflected on the responses received by the students.

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.

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 share by the 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 that were faced, especially on the crafting, the circuit making process and the programming of the DIY robotic car.

Project 2 (Autonomous driving vehicle recognizing traffic signs) evaluation

Project 2 was implemented by 57 students, ages from 15 to 17 years old, in three different countries (i.e., Greece, Italy and Spain)[4]. Unlike the previous project, which was an Arduino based project, this revolved around the Raspberry Pi technology. This project was also focusing on the creation of a robotic car (a Raspberry Pi -based one) but in this case the car will be able to recognize traffic signs and accordingly act (*Figure 3*). It was also estimated to be completed in 8 hours, divided in 4 sessions (i.e., 2 hours per session). Specifically, a two-hour session (1st session) was estimated for introducing students to concepts related to AI, and particularly to image classification and object recognition, as well as to topics related to autonomous vehicles. The next session (2nd session) was destined for the creation and the programming of the robotic car. After that, 4 more hours in total (3rd and 4th session) would be needed for training the image classification model, integrating it in the robotic vehicle and testing, as well as for integrating a pre-trained object recognition model, and raising a discussion regarding the differences between the two methods (i.e., image classification and object recognition). To ease the process, students' worksheets would be provided during different steps of the implementation.

Again, due to Covid19 restrictions, the implementation was made in teams of 2 or 3 students. The majority of students who implemented this project did not have any previous experience with Raspberry Pi technology. They did have some previous experience on programming but not on python language and they were not familiar with the Raspberry operating system. Therefore, more time needed not only for introducing students to concepts related to image classification and object recognition, as well as to Machine Learning processes, but also to introduce them on Raspberry Pi technology, and on python programming environment.

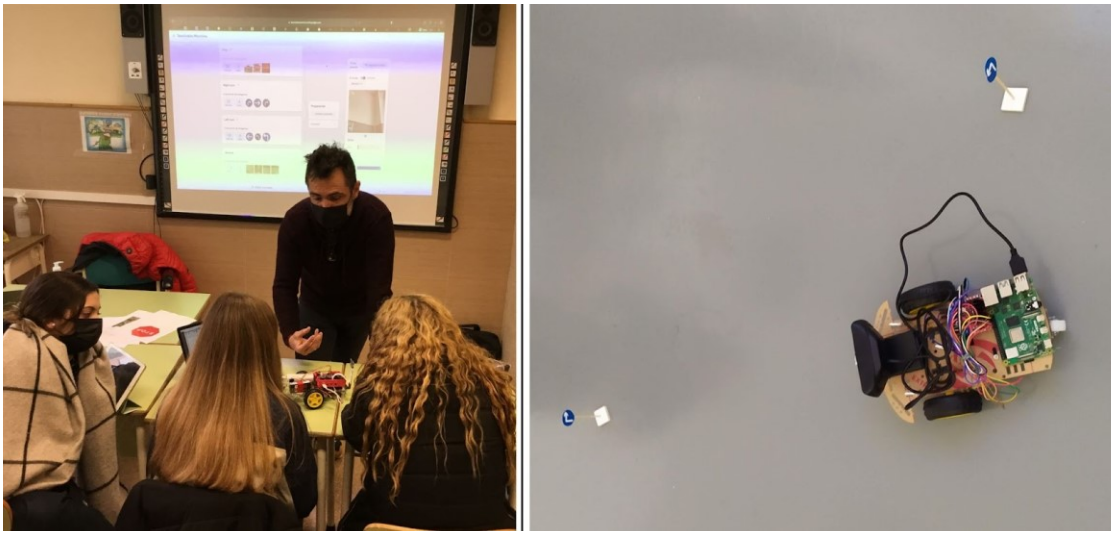

Figure 3: Piloting project 2 in Spain and Greece: Images from the introductory phase to teachable machine and the testing process by using paper models of traffic signs

For these reasons, the actual time needed for completing the project varied from 20 to 40 hours, and it was also a project that was perceived both by teachers and students as a project of average difficulty. In this case, regarding the question "In a scale of 1 (very easy) to 5 (very difficult), how easy or difficult was this project", the mean average was equal to 2,96, indicating that this project was also one of the most demanding contained in the handbook (*Table 5*). Despite the difficulties and the needed workload for completing the project – and apart from some frustration that emerged due to difficulties on programming - the teachers stated that students did enjoy this project. Especially students who haven't implemented the previous

[4] Video presenting teachers' and students' experiences of Project 2: https://www.youtube.com/watch?v=YvEQDojjY90

project, were thrilled when they managed to set their robotic car in motion. These statements are also reflected in the results received from questionnaires. The mean average to the corresponding question was equal to 4,30, turning this into one of the most favorite projects.

	1	2	3	4	5
How did you like this project - In a scale of 1 (not at all) to 5 (a lot) -	0	2	7	20	**28**
How easy or difficult was this project for you - In a scale of 1 (very easy) to 5 (very difficult) -	4	15	**21**	13	4

Table 5: Results from students' questionnaires regarding how much they liked the project and how difficult they think it was

According to teachers the most valuable aspect of this project was the gained knowledge on working with an AI technology that raised discussions regarding the benefits and the challenges laying behind such practices. Teachers from Spain stated that their students (who had already implemented Project 1) felt more confident to explain what AI is after the implementation of this project. For students who hadn't implemented Project 1, it was also important the fact that they had the opportunity to create their own robot from scratch, by starting with the crafting and moving forward to the programming process, thus breathing some life to the robotic artefact.

Some of these statements are also reflected in the feedback received by the students through the evaluation forms (i.e., questionnaires). Regarding how comfortable/confident they felt to explain different aspects of AI and ML after the implementation of this project, again the majority of answers are 'Yes' and/or 'A bit', but in this case there are more students who choose 'Yes' as an answer (*Table 6*). In particular, and regarding explaining what AI is, 36 students replied 'Yes' and 17 'A bit', while 4 answered 'Not at all'. Regarding their feelings towards explaining how AI can be used in real life, 34 students chose 'Yes' as an answer, and 20 'A bit'. Something similar is also reflected in the answers that students gave when they were asked to express how comfortable they were feeling to explain what ML does. Unlike Project 1, Project 2 did include activities related to Machine Learning, therefore students were more positive towards this aspect. Specifically, 31 chose 'Yes', and 23 'A bit' as an answer, while there were 3 students who stated that they did not feel comfortable at all to explain what ML does, after the implementation of this project. The same applies for the question regarding if they were feeling comfortable on experimenting with AI projects, and built and program an AI artefact, since 23 students declared that are feeling 'A bit" confident, 29 of them replied 'Yes', 4 of them replied 'Not at all' and 1 chose 'Not applicable' (*Table 6*).

After this project I feel comfortable to	Yes	A bit	Not at all	Not applicable
Explain what AI is	**36**	17	4	0
Explain what ML does	**31**	23	3	0
Explain how AI can be used in real life	**34**	20	3	0
Experiment with AI projects, building and programming an AI artefact	**29**	23	4	1

Table 6: Results from students' questionnaires reflecting their attitude towards AI and ML

Moreover, 29 students declared that they might use the gained knowledge and skill in a similar project. 26 answered that they will definitely use the gained knowledge and 2 replied that they weren't sure or didn't know at that point (*Table 7*). Regarding motivation on learning more about

AI, 36 students declared that they have been definitely motivated, 18 declared that they might be motivated, 2 claimed that they were definitely not being motivated and 1 wasn't sure, or didn't know at that point. Again, based also on feedback received by the teachers, these results can be interpreted as a rather positive attitude of the students towards these aspects.

	Definitely Yes	Maybe	Definitely No	Don't know/Not sure
I feel I can use the gained knowledge and skills in new similar projects	26	**29**	0	2
This project has motivated me to learn more about AI	**36**	18	2	1

Table 7: Results from students' questionnaires concerning gained knowledge and motivation

Regarding the produced material aiming on assisting both teachers and students toward the implementation of this project (i.e., teacher's guidelines and students' worksheets), the results are not as positive as in other projects. Teachers agree with or feel neutral about the statement regarding the content of teacher's guidelines, and whether or not this document was helpful towards organizing and planning this project. Also, they agreed with or they felt neutral about the statement regarding the usefulness of students' worksheets. This is not reflected on the responses received by the students, who generally believe that the worksheets were actually useful.

Concerning any future improvement of this project, teachers recorded that there should be more time for the entire project as well as for learning or, at least, introducing Python. They also suggested that some info and ideally some introductory material should be provided in relation to Raspberry PI and Python, making educators more confident on introducing and teaching this project to students. They also reported that some updates on teacher's guidelines should be made to be in-line with the latest version of Raspberry Pi OS. Moreover, (and again according to their opinion) 3D design and 3D printing should be considered as additions in order to be able to produce different solutions regarding the shape of the chassis, thus tackling problems emerging from this part of crafting. Another idea for boosting the concept of autonomous driving was the creation of a specific route that will be followed by the robotic car. There was a proposal for encouraging the collaboration among more teachers in order to better implement the project. An interesting fact that was also reported concerned difficulties on binding the trained model to the robotic car, and the use of methods proposed in Project 1 instead (i.e., programming on MIT App Inventor) in order to tackle this problem.

In general, and according to the evaluation received through questionnaires, the "Autonomous driving vehicle recognizing traffic signs" is also a project that the majority of the students did like, even though they faced some difficulties, especially regarding the programming process. This project is also perceived as an opportunity to widen and enhance the curriculum with new technologies, while motivating students to collaborate on finding solutions to immanent problems.

Project 3 (Virtual Secretary Office Chatbot) evaluation

This project was implemented by 30 students, ages from 16 to 18 years old, in two different countries (i.e., Greece and Spain) (*Figure 4*)[5]. Unlike previous projects, which contained hands-on practices, this was an exclusively computer-based project. The estimation for the implementation of this project was 8 hours in total, divided in 4 sessions (i.e., 2 hours per session). The content of each session was not dictated, but it was suggested that during these 8 hours the following parts should be covered: becoming familiar and learning DialofFlow environment, creating a chatbot that can correspond to specific questions, and displaying as well as testing the chatbot trough Telegram application. In this last part, java is also suggested to be introduced. Like previous projects, students' worksheets were provided to ease the implementation.

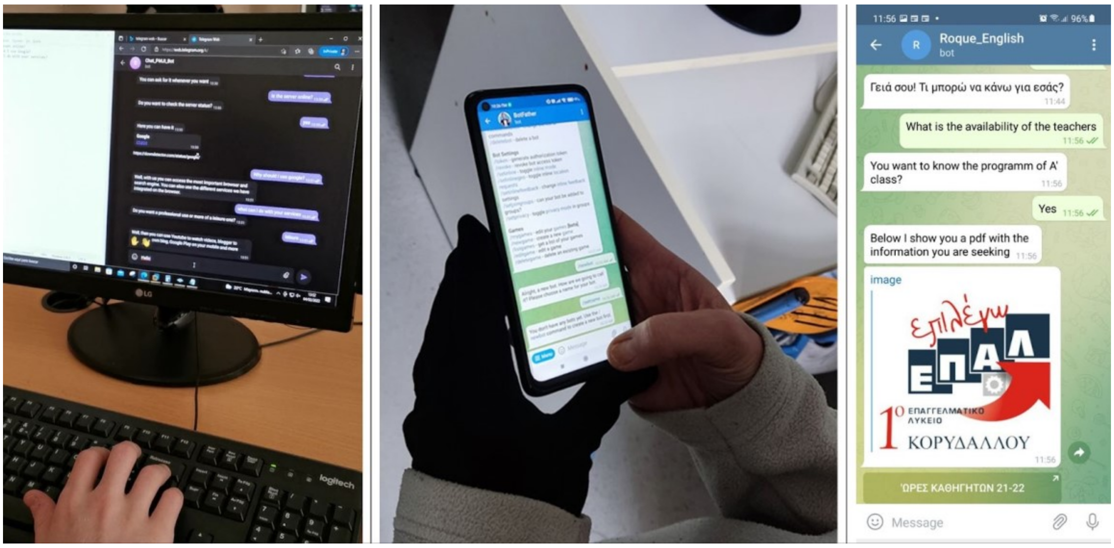

Figure 4: Piloting Project 3 in Spain and Greece: Students interacting with the produced chatbots

The actual time needed for completing the project varied from 4 to 9 hours. Concerning previous programming knowledge, the background of students who implemented this project varied. Some of them had no previous experience (students from Greek school) while others (students from Spanish school) had some experience in programming. In both cases, the project was implemented without any significant difficulties. The content of teacher's guidelines was in general considered sufficient, and the teachers perceived this project as less demanding regarding the needed preparation toward the implementation. Teachers in Greece reported that they needed to do some supplementary work, since the Greek version of DialogFlow environment has some significant differences, but overall, both teachers and students did not face any significant problem. This is also reflected by students' response regarding the difficulty of this project, since the mean average was equal to 2,63 (*Table 8*).

Both students in Greece and Spain created a secretary office chatbot. The teams of students in Spain were also encouraged to exchange their chatbots in order to test if the chatbot of another team was properly working, making the entire process more entertaining. Teachers reported that the students did like this project. This was also reflected by students' answers in the question "How did you like this project". In this case the mean average was equal to 4,03 indicating that students did enjoy the process of creating a chatbot (*Table 8*).

[5] Video presenting teachers' and students' experiences of Project 3: https://www.youtube.com/watch?v=JbofmlFFW7o

	1	2	3	4	5
How did you like this project - In a scale of 1 (not at all) to 5 (a lot) -	0	1	6	**14**	9
How easy or difficult was this project for you - In a scale of 1 (very easy) to 5 (very difficult) -	3	7	**18**	2	0

Table 8: Results from students' questionnaires regarding how much they liked the project and how difficult they think it was

According to teachers, the most valuable aspect of this project was that the students not only learned what a chatbot is, but they also learned how to create one. Regarding AI, teachers from Spain declared that their students were motivated to learn more about AI after the implementation of this project. Concerning any future improvement, there was a suggestion for enriching this project with the creation of a robotic artifact (like a humanoid robot) which would display in some way all the available information that this robot is programmed to answer, but the creation of such an advanced artefact goes beyond the scopes of this project.

The results from students' questionnaires concerning how comfortable/confident they felt to explain different aspects of AI and ML after the implementation of this project, indicate a positive attitude towards these aspects (*Table 9*). In particular, and regarding explaining what AI is, there were 13 students who replied 'Yes' and 13 'A bit'. Regarding their feelings towards explaining how AI can be used in real life, 16 students chose 'Yes' as an answer, and 9 'A bit'. As far as ML is concerned and how confident/comfortable they were feeling to explain what ML does, there were only 8 students who chose 'Yes' as an answer, while 17 chose 'A bit'.

Contrariwise to the previous two projects, in this one there were many students who claimed that they did not feel comfortable at all on experimenting with AI projects, and built and program an AI artefact, after the implementation of this project. In particular, 10 students out of 30 chose "Not at all" as an answer to this question and 2 marked "Not applicable", while 14 students declared that they are feeling 'A bit" confident, and only 4 replied 'Yes'. A question that can emerge from this finding is whether or not the enhancement of this project with hands-on activities would lead to boosting the confidence of students as far as the aforementioned dimension is concerned.

After this project I feel comfortable to	Yes	A bit	Not at all	Not applicable
Explain what AI is	**13**	**13**	4	0
Explain what ML does	8	**17**	4	1
Explain how AI can be used in real life	**16**	9	4	1
Experiment with AI projects, building and programming an AI artefact	4	**14**	10	2

Table 9: Results from students' questionnaires reflecting their attitude towards AI and ML

This project was also the one with the most responses on the "Don't know/ Not sure" field, regarding the implementation of the gained knowledge in a similar project (*Table 10*). In particular, 8 students declared that they 'Don't know" or that they are "Not sure", 17 declared that they might use the gained knowledge and only 5 that they will definitely use the gained knowledge.

Regarding motivation on learning more about AI, a more positive attitude was recorded, since 14 students declared that they have been definitely motivated, 12 stated that they might have been motivated, 1 claimed that was definitely not being motivated and 3 weren't sure, or didn't know at that point (*Table 10*).

	Definitely Yes	Maybe	Definitely No	Don't know/Not sure
I feel I can use the gained knowledge and skills in new similar projects	5	**17**	0	8
This project has motivated me to learn more about AI	**14**	12	1	3

Table 10: Results from students' questionnaires concerning gained knowledge and motivation

Regarding the produced material aiming to assist both teachers and students toward the implementation of this project (i.e., teacher's guidelines and students' worksheets), teachers agreed or strongly agreed with the statement regarding the content of teacher's guidelines, and whether or not it was helpful towards organizing and planning this project. However, they agreed with or they felt neutral about the statement regarding the usefulness of students' worksheets. This is partially reflected on the responses received by the students, who generally believe that the worksheets were useful, but the mean average was less than the two previous projects.

In general, and according to the evaluation received both through students' and teachers' questionnaires as well as through the discussions with teachers, the "Virtual Secretary Office Chatbot" is also a project that the majority of the students did like and helped them gain some knowledge on the field of AI and ML.

Project 4 (Face Recognition) evaluation

The fourth project was implemented by 51 students, ages from 14 to 18 years old, in two different countries (i.e., Greece and Italy) (*Figure 5*)[6]. This was also an exclusively computer-based project (i.e., no hands-on tasks were included), and was the only one offering two solutions and therefore two levels of complexity/difficulty: namely the basic and the advanced one. Through the basic solution students learned how to create and program and emotional recognize app that will be able to recognize facial expressions – and this solution is suggested to be implemented through mBlock block-based programming environment, while through the advanced solution students learn to develop a facial recognition system, by using the Anaconda programming environment.

Figure 5: Piloting Project 4 in Greece: images from the introduction and the testing phase

The estimation for implementing both solutions was 10 hours in total, divided in 5 sessions (i.e., 2 hours per session). Through the proposed sessions students would begin with the implementation of the basic solution, and progressively – through delving into concepts related to face recognition processes – would manage to develop their own facial recognition system. Like previous projects, students' worksheets were provided to ease the implementation.

However, the teachers mainly focused on the basic solution since the students who participated in this project did not have any previous experience on programming. Therefore, the actual time of implementation varied from 2 to 6 hours. Regarding difficulty – and compared to the other projects – this project (and mostly the basic solution) was also perceived as a less demanding one. The mean average of the responses to the corresponding question was equal to 2,63 (*Table 11*). Still the students did like this project, and based on teachers' reports they mostly liked the testing process (i.e., showing their face on camera and observing how the expressed emotions were perceived by the application). This is also indicated from the responses to the questionnaire, since the mean average to the corresponding question was equal to 4,14[7].

	1	2	3	4	5
How did you like this project - In a scale of 1 (not at all) to 5 (a lot) -	2	1	8	17	**23**
How easy or difficult was this project for you - In a scale of 1 (very easy) to 5 (very difficult) -	10	8	**26**	5	2

Table 11: Results from students' questionnaires regarding how much they liked the project and how difficult they think it was

[6] Video presenting teachers' and students' experiences of Project 4: https://www.youtube.com/watch?v=qrYcJe9Lp-c

[7] 23 students chose 5, 17 chose 4, 8 chose 3, 1 chose 2 and 2 chose 1

Regarding explaining what AI is, 41 of the students replied ‘Yes’ and 10 replied ‘A bit’ (*Table 12*). Concerning their feelings towards explaining how AI can be used in real life, 34 students chose ‘Yes’ as an answer, 15 ‘A bit’, 1 ‘Not at all’ and 1 declared ‘Not applicable’. As far as ML is concerned and how confident/comfortable they were feeling to explain what ML does, 33 students answered ‘Yes’, 17 ‘A bit’, and 1 chose ‘Not applicable’. Concerning how comfortable they were feeling on experimenting with AI projects, and building and programming an AI artefact, after the implementation of this project, 37 students answered ‘Yes’, 11 answered ‘A bit’, 2 “Not at all’ and 1 ‘Not applicable’.

After this project I feel comfortable to	Yes	A bit	Not at all	Not applicable
Explain what AI is	**41**	10	0	0
Explain what ML does	**33**	17	0	1
Explain how AI can be used in real life	**34**	15	1	1
Experiment with AI projects, building and programming an AI artefact	**37**	11	2	1

Table 12: Results from students’ questionnaires reflecting their attitude towards AI and ML

As far as the implementation of the gained knowledge in a similar project is concerned, there was a positive attitude, since 21 declared that they might use the gained knowledge and 28 that they will definitely use the gained knowledge, while there were 2 students who didn’t know or weren’t sure at that point (*Table 13*). Regarding motivation on learning more about AI, the majority of the responses were also positive, with 23 students declaring that they have been definitely motivated, 25 stating that they might have been motivated, and only 3 claiming that they weren't sure, or didn’t know at that point.

	Definitely Yes	Maybe	Definitely No	Don’t know/Not sure
I feel I can use the gained knowledge and skills in new similar projects	**28**	21	0	2
This project has motivated me to learn more about AI	23	**25**	0	3

Table 13: Results from students’ questionnaires concerning gained knowledge and motivation

Regarding the produced material aiming to assist both teachers and students toward the implementation of this project (i.e., teacher’s guidelines and students’ worksheets), teachers claimed that the teacher’s guidelines were helpful, but the majority of them was skeptical about the usefulness of students’ worksheets. However, this is not reflected on the responses received by the students, who generally believe that the worksheets were useful, with the mean average being equal to 3,94.

A valuable aspect that was stressed by the teachers is the opportunity that students had to become engaged in an activity showcasing an example of using machine learning, thus adding a practical dimension to a rather theoretical and abstract concept. Concerning any future improvement of this project, there was a suggestion to enhance this project with activities proposed by students. Apart from this there were no further suggestions or recommendations, even though they reported that there were some difficulties in the coding process.

Project 5 (Open Sesame) evaluation

This project was implemented by 31 students, ages from 13 to 17 years old, in two different countries (i.e., Germany and Spain). This is the second Arduino-based project included in the handbook, and the second in row revolving around face recognition AI service. In project 5 a trained model is used for the creation of a smart door that opens when a person is detected wearing a Covid-19 facial cover. Therefore, this project also couples hands-on practices (i.e., creation of an Arduino-based robotic artefact) with AI and ML methods (i.e., face recognition, image classification). In this case, teachable machine is used for the creation and production of the trained model, and Pictoblox block-based programming environment for assembling the script for the smart door and for binding the trained model on the produced robotic artefact.

Figure 6: Piloting Project 5 in the Spanish partner school: Implementing the project in the framework of a larger project (i.e., DOMOTICs)

The estimation for implementing this project was 3 to 4 hours. Unlike previous projects, there was not any suggestion regarding the content of each session and which aspects of the project are expected to be covered during each session. The actual time of implementation varied from 5 to 6 hours while the student who implemented this project did have some previous experience on programming or on Arduino-based technologies There were slight modifications in both countries regarding the scenario of this project. In particular, in German school due to existing restrictions regarding sensitive data (i.e., pictures of students are not allowed), the model was trained to recognize if a person wears protective glass or not before entering to the lab, while in the Spanish school this project was integrated in a larger one which was about the creation of a smart/autonomous house (i.e., Domotics) (*Figure 6*). In general, both of the partner schools did not face any significant difficulties during the implementation. In Spanish school there were some minor problems with circuitry, but due to previous experience (due to the implementation of Projects 1 and 7) these difficulties were manageable, while they highlighted some issues on the trained model which were related to the color of the mask. The major difficulties that were faced were on crafting and on finding ways to bind the servo motor on the paper model, but still these problems were not that significant, and did not discourage students to complete the project. This is also reflected by students' responses to the question regarding the difficulty of this project. The mean average of this question was equal to 2,61 indicating that this project was considered almost as difficult as Projects 3 and 4 (*Table 14*).

Teachers reported that in general students did enjoy this project. This is in-line with the finding from the questionnaires since the mean average on this question was equal to 3,84. Compared to the other projects this was the least favorite one for students, but this value is still considered rather high.

	1	2	3	4	5
How did you like this project **-** In a scale of 1 (not at all) to 5 (a lot) **-**	1	1	8	**13**	8
How easy or difficult was this project for you **-** In a scale of 1 (very easy) to 5 (very difficult) **-**	5	8	**13**	4	1

Table 14: Results from students' questionnaires regarding how much they liked the project and how difficult they think it was

Regarding how comfortable/confident they felt to explain different aspects of AI and ML after the implementation of this project, the majority of answers are indicating a positive attitude. In particular, and regarding explaining what AI is, 14 students replied 'Yes' and 14 'A bit' (*Table 15*). Regarding their feelings towards explaining how AI can be used in real life, 17 students chose 'Yes' as an answer, and 8 'A bit'. As far as ML is concerned and how confident/comfortable they were feeling to explain what ML does, 16 students answered 'Yes', and 10 'A bit'. 4 students didn't feel confident to explain what ML does after the implementation of this project, and 1 replied 'Not applicable'.

Concerning how comfortable they were feeling on experimenting with AI projects, and building and programming an AI artefact, after the implementation of this project, 10 students replied 'Yes', 17 answered 'A bit', 2 "Not at all" and 2 "Not applicable' (*Table 15*). This finding might be connected to the issues that were faced during crafting.

After this project I feel comfortable to	Yes	A bit	Not at all	Not applicable
Explain what AI is	**14**	**14**	1	2
Explain what ML does	**16**	10	4	1
Explain how AI can be used in real life	**17**	8	4	2
Experiment with AI projects, building and programming an AI artefact	10	**17**	2	2

Table 15: Results from students' questionnaires reflecting their attitude towards AI and ML

The majority of the students were positive towards using the gained knowledge and skill in new similar projects. In particular, 14 students answered "Definitely yes", 13 replied "Maybe", only 1 claimed that they would "Definitely not" use the gained knowledge and 3 that weren't sure (*Table 16*).

As far as motivation on learning more about AI is concerned, there were still many positive answers, since 12 students declared that they have been definitely motivated, and 10 stated that they might have been motivated, but there were 7 students who weren't sure or they didn't know at that point, if they had been motivated.

	Definitely Yes	Maybe	Definitely No	Don't know/Not sure
I feel I can use the gained knowledge and skills in new similar projects	**13**	12	1	3
This project has motivated me to learn more about AI	**12**	8	2	7

Table 16: Results from students' questionnaires concerning gained knowledge and motivation

Referring to the produced material aiming to assist both teachers and students toward the implementation of this project (i.e., teacher's guidelines and students' worksheets), teachers agreed that both of these resources were useful and helped them towards the planning and the implementation of the project. This is partially reflected on the responses received by the students, who were less enthusiastic about the usefulness of the worksheets for this project.

In general, and according to the evaluation received through questionnaires, but also through the discussion with teachers, the "Open Sesame" is also a project that students liked. According to teachers the most valuable aspect of this project was that students were introduced to image classification and that this project was an opportunity for expanding the curriculum with new technologies. However, there were some concerns whether students should be 'exposed' by showing their face or not. These concerns led to a suggestion on slightly changing the scenario of the project in order to avoid storing in public domains images with the faces of the students. One solution that is showcased in the examples provided in teacher's guidelines is the use of a toy (e.g., a teddy-bear) and the production of a trained model based on whether or not the toy is wearing a Covid-19 mask. Another issue that was highlighted was related to the color of the mask and the inability of the trained model to recognize some of the existing facial covers. It was proposed that a model with more categories should be created but it was argued that such an enhancement might lead to more problems instead of tackling the problem.

An important comment that was also made at this point (since for some students this was the third or fourth project in a row) was related to the questionnaires that were used as an evaluation tool. Specifically, and since the items contained to the questionnaires were the same for all the projects, there was a concern whether or not students' answers were biased and were effected by some kind of learning effect. This might be a valid point for some cases, but since in some countries the projects were implemented by different students, it is argued that, in general, the findings are reliable.

Project 6 (Voice recognition with Arduino board) evaluation

The sixth project was implemented by 38 students, ages from 12 to 14 years old, in four different Italian schools. This was an exclusively Arduino-based project coupling voice recognition AI technology with hands-on tasks. By using a special electrical component (Elechouse V3 voice recognition module) and a relevant library on Arduino IDE programming environment, students trained a model to recognize voice commands, and used this model to perform different kind of actions/tasks in a paper model of a house (i.e., turn on or off a LED light, open a door etc.) (*Figure 7*). The estimation for implementing this project was 5 hours in total, divided in 3 sessions (i.e., 1.5 to 2 hours per session). Through the proposed sessions students would initially become familiar with the electronical components in order to gradually assemble the circuit and install the library for training (session 1). Then they would train and test the model and incorporate it on a paper model in which a LED light would be turned on or off, based on the incoming command (session 2). Finally, they would extend the project by adding more components, such as buzzers and servo motors (session 3). Like previous projects, students' worksheets, with half-baked solutions and tips, were provided to ease the implementation.

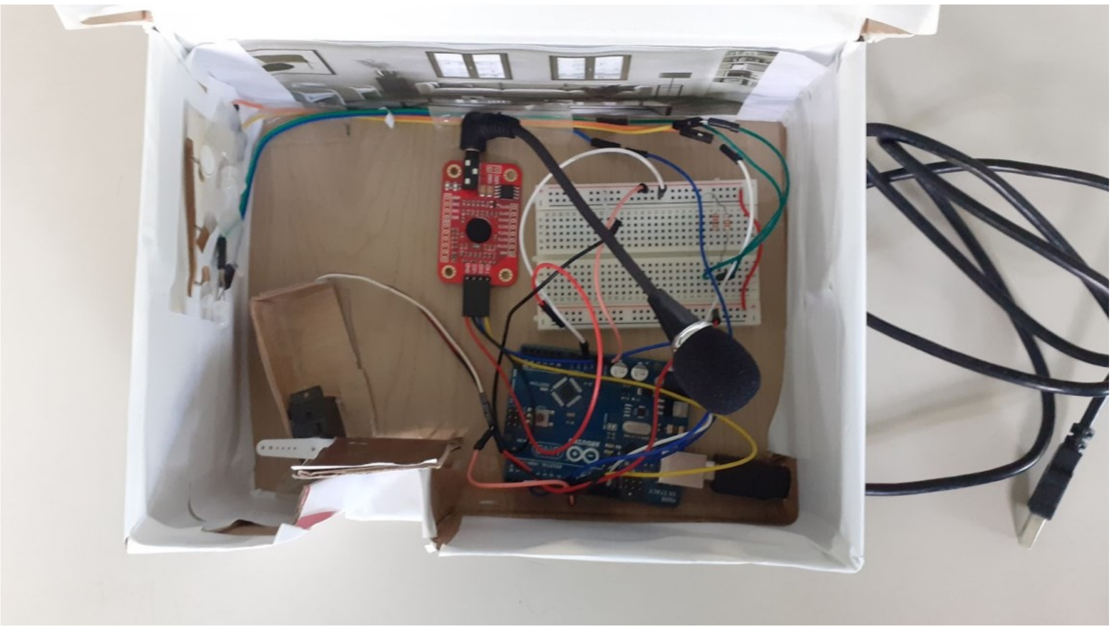

Figure 7: Piloting Project 6 in Italian partner school: Image of a paper model produced during the implementation of the project

The students who implemented this project have some experience with electronic components, therefore the introduction to the project was rather easy. The fact that they worked with semi-structured code also helped them towards the implementation. Some difficulties that were faced were during the training process and mostly due to ambient noise. Crafting was also a demanding process, and was the reason that the actual time of implementation varied from 10 to 15 hours. However, this did not discourage the students, who in general perceived this project as the easiest one (of those contained in the handbook). The mean average to the corresponding question was equal to 2,37, indicating that this project was the least demanding (*Table 17*). The crafting process was actually perceived as an added value from students, since they felt that they were working on a real-case scenario. This is also reflected on their answers regarding the question if they did like this project. The mean average to this question was equal to 4,5, a rather high mean average indicating that most of the students did enjoy this project[8].

[8] 24 students chose 5, 9 chose 4, and 5 chose 3 / unlike previous projects, this project was implemented only in Italian schools

	1	2	3	4	5
How did you like this project - In a scale of 1 (not at all) to 5 (a lot) -	0	0	5	9	**24**
How easy or difficult was this project for you - In a scale of 1 (very easy) to 5 (very difficult) -	**14**	4	**14**	4	2

Table 17: Results from students' questionnaires regarding how much they liked the project and how difficult they think it was

Concerning how comfortable/confident they felt to explain different aspects of AI and ML after the implementation of this project, again a positive attitude was recorded. According to the findings, and regarding explaining what AI is, 32 students replied 'Yes' and 6 'A bit' (*Table 18*). In the question about their feelings towards explaining how AI can be used in real life, 32 students answered 'Yes', 5 'A bit' and 1 'Not at all'. This finding might also reflect the importance of crafting in this project, which helped students to perceive this project as a real case scenario. As far as explaining what ML does, 24 students replied 'Yes' and 11 replied 'A bit'. 3 students felt that this aspect is 'Not applicable' in this project.

Regarding how comfortable they were feeling about experimenting with AI projects, and building and programming an AI artefact, after the implementation of this project, 14 students replied 'Yes', 21 answered 'A bit', 2 "Not at all" and 1 "Not applicable'.

After this project I feel comfortable to	Yes	A bit	Not at all	Not applicable
Explain what AI is	**32**	6	0	0
Explain what ML does	**24**	11	0	3
Explain how AI can be used in real life	**32**	5	1	0
Experiment with AI projects, building and programming an AI artefact	14	**21**	2	1

Table 18: Results from students' questionnaires reflecting their attitude towards AI and ML

In the question if they feel they can use the gained knowledge and skill in new similar projects, 24 students answered "Definitely yes", and 14 replied "Maybe" (*Table 19*). Regarding motivation on learning more about AI, 28 students declared that they have been definitely motivated, and 7 stated that they might have been motivated, while there were 3 students who stated they weren't sure or didn't know at that point.

	Definitely Yes	Maybe	Definitely No	Don't know/Not sure
I feel I can use the gained knowledge and skills in new similar projects	**24**	14	0	0
This project has motivated me to learn more about AI	**28**	7	0	3

Table 19: Results from students' questionnaires concerning gained knowledge and motivation

Regarding the produced material aiming to assist both teachers and students toward the implementation of this project (i.e., teacher's guidelines and students' worksheets), both teachers and students agreed that these resources were useful and helped them towards the planning and/or the implementation of the project.

In general, and according to the evaluation received through questionnaires, but also through the following discussion with the teachers, the "Voice recognition with Arduino board" is also a project that students liked. Based on teachers' feedback some valuable aspects highlighted were about the importance of implementing AI skills related to voice commands, as well as about engaging the students in an activity based on real world problems, that also aims to make the life of some people easier, especially those with disabilities. The proposed improvements revolve around possible extensions of the current scenario by adding more electronic components to the circuitry, as well as on how optimizations on the recording process can be done (e.g., adding a filter that isolates noises).

Project 7 (Device that turns audio to visual signs) evaluation

The seventh project was implemented by 30 students, ages from 15 to 18 years old, in three different countries (i.e., Germany, Greece and Spain) (*Figure 8*)[9]. This is the fourth Arduino-based project included in the handbook and revolves around the creation of a device for domestic use that aims to help people with hearing loss by turning audio events that can occur to a house to visual signs. It couples sound recognition and audio classification methods with hands-on practices. Specifically, students train a model to recognize different sounds, and then create and program an application that uses this trained model to classify incoming sounds and based on the result to instruct the device to blink a light (e.g., red light if the incoming sound is classified as an alarm). The estimation for implementing this project was 6 hours in total, divided in 3 sessions (i.e., 2 hours per session). Through the proposed sessions students would initially create and program the Arduino-based device (session 1). Then they would train a model for classifying different sounds (session 2) and finally they would create and program an application (in MIT app Inventor) that would record incoming sounds, classify them by using the trained model and (based on the classification result) instruct the device to blink the corresponding light (session 3). Like previous projects, students' worksheets, with half-baked solutions, circuit maps and tips, were provided to ease the implementation.

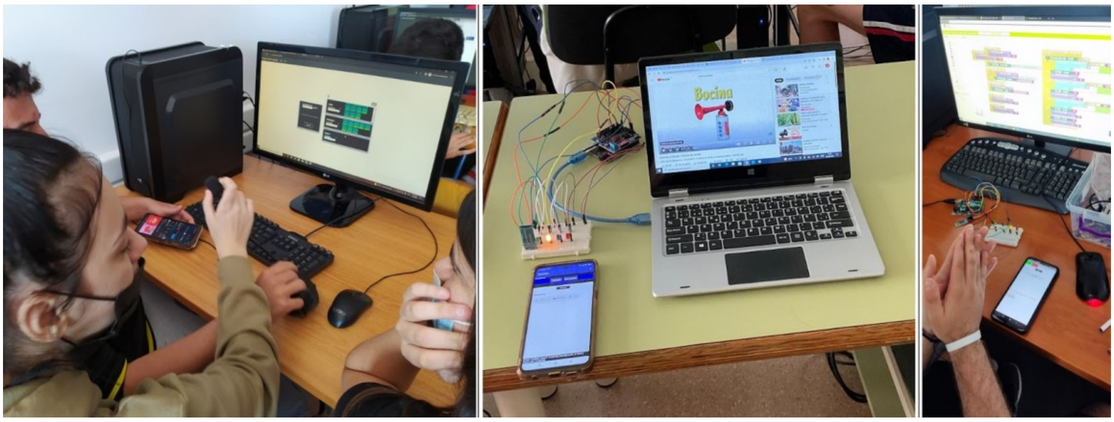

Figure 8: Piloting Project 7 in Greek and Spanish partner schools: Images of the training and the testing process

Figure 7: Piloting Project 7 in greek and spanish partner school: Images of the training and the testing process

The students who implemented this project have some experience with programming as well as with Arduino technology (due to the implementation of the previous projects). Therefore, teachers did not face any significant problem on familiarizing students with the proposed technologies. However, they reported problems during the training process. One problem that was faced was the reliability of the recorded samples due to the small margin for recording that is provided by the training environment of App Inventor (i.e., Personal Audio Classifier). Another significant problem was that the environment for training the model proved to be unstable if too many samples were recorded, leading to loss of data and probably frustration. To tackle this latter problem, students were encouraged to create less categories of classified sounds, or to record less samples per category. There were also some minor difficulties with crafting but in general the problems were less than those faced during the first two projects. Due to the aforementioned parameters, the actual time of the implementation varied from 5 to 15 hours, and overall, this project was perceived as a demanding one but not as much as Project 1 and 2. This is also reflected by the answers that students gave to the corresponding question. With a mean average equal to 2,90, this project seems to be considered as the third most difficult project, after Project 1 and Project 2 (*Table 20*).

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[9] Video presenting teachers' and students' experiences of project 7: https://www.youtube.com/watch?v=DVR9pqzcCzA

Despite the difficulties, teachers reported that students did enjoy this process. For some students this project was a playful way for interacting with AI. In the case of Spanish school – and like Project 5 - this project was also integrated in a larger one (Domotics), thus emphasizing on aspects related to project interconnectivity and interdisciplinarity. The teachers' report is verified by the findings on the questionnaire. Regarding the question if students did like this project the mean average was equal to 4 (*Table 20*), indicating that the majority of students actually did like project 7[10].

	1	2	3	4	5
How did you like this project - In a scale of 1 (not at all) to 5 (a lot) -	1	1	4	**15**	9
How easy or difficult was this project for you - In a scale of 1 (very easy) to 5 (very difficult) -	2	6	**16**	5	1

Table 20: Results from students' questionnaires regarding how much they liked the project and how difficult they think it was

According to teachers the most valuable aspect of this project was the opportunity that students had to use the Arduino technology combined with the App Inventor programming environment to work on a real-case scenario, as well as that this project was an opportunity for expanding the curriculum with new technologies. However, it was still reported that students did understand how the specific AI technology works but they couldn't understand the core mechanisms laying behind AI and ML.

Based on the answers to the questionnaires, and concerning how comfortable/confident students felt to explain different aspects of AI and ML after the implementation of this project, again a positive attitude was recorded. In particular, and regarding explaining what AI is, 16 students replied 'Yes' and 13 'A bit' (*Table 21*). Regarding their feelings towards explaining how AI can be used in real life, 15 students answered 'Yes', and 13 'A bit'. As far as ML is concerned and how confident/comfortable they were feeling to explain what ML does, 9 students replied 'Yes' and 17 replied 'A bit'. 3 students didn't feel confident to explain what ML does after the implementation of this project, and 1 replied 'Not applicable'. These findings might reflect the teachers' statement regarding the extent to which students comprehend the concepts of AI and ML. Referring to how comfortable they were feeling about experimenting with AI projects, and building and programing an AI artefact, after the implementation of this project, 10 students replied 'Yes', 17 answered 'A bit', 1 "Not at all" and 2 "Not applicable' (*Table 21*).

After this project I feel comfortable to	Yes	A bit	Not at all	Not applicable
Explain what AI is	**16**	13	1	0
Explain what ML does	9	**17**	3	1
Explain how AI can be used in real life	**15**	13	1	1
Experiment with AI projects, building and programming an AI artefact	10	**17**	1	2

Table 21: Results from students' questionnaires reflecting their attitude towards AI and ML

[10] 9 students chose 5, 15 chose 4, 4 chose 3, 1 chose 2 and 1 chose 1

All the students were – to a certain extent – positive towards using the gained knowledge and skill in new similar projects. In particular, 13 students answered “Definitely yes”, and 17 replied “Maybe” (*Table 22*). Regarding motivation on learning more about AI, there were still many positive answers, since 14 students declared that they have been definitely motivated, and 12 stated that they might have been motivated. However, there were 3 students who stated that they definitely were not motivated towards learning more about AI and 1 that wasn’t sure or didn’t know at that point.

	Definitely Yes	Maybe	Definitely No	Don’t know/Not sure
I feel I can use the gained knowledge and skills in new similar projects	13	**17**	0	0
This project has motivated me to learn more about AI	**14**	12	3	1

Table 22: Results from students’ questionnaires concerning gained knowledge and motivation

Concerning the produced material aiming to assist both teachers and students toward the implementation of this project (i.e., teacher’s guidelines and students’ worksheets), teachers agreed that both of these resources were useful and helped them towards the planning and the implementation of the project. This is partially reflected in the responses received by the students, who in the majority did find the worksheets useful, but there were also many neutral responses.

Overall, and according to the evaluation received both through questionnaires and through discussion with teachers, the “Device that turns audio into visual signs” is also a project that students liked and found interesting to work on.

Some proposed improvements concerned the training environment and features that would be interesting if they could be supported by the App Inventor software (such as interchangeability of the dataset to minimize the training time, having the option of sound editing etc.). The use of a shield for making the circuit making process easier was also included in the suggestions for improvement. A significant suggestion was about the order that projects should be applied. Teachers stated that if they had begun with this one or with any of the previous two projects (i.e., Project 5 or Project 6), they would have spent less time on the preparatory phase they needed for project 1.

Project 0 (Introduction and overview of artificial intelligence) evaluation

Apart from the aforementioned 7 projects that were piloted and evaluated both by students and teachers, the collection of lessons for introducing the basic concepts of AI and ML in school classes (i.e., Project 0) was piloted by students who attend the German partner school (*Figure 9*), leading to some interesting results regarding the content of these 18 lessons and their added value as learning activities included in a handbook that aims to introduce AI and ML to secondary school education. The idea of creating these lessons came from the fact that the AI and ML concept might be new, but they are not compulsory, leading to questioning how these projects can be better introduced in the framework of a school curriculum. Another fact that led to the creation of these lessons was the flexibility that German schools have regarding the content of the curriculum. In particular, 20% of the curriculum can be defined from the school, thus giving freedom on how subjects can be shaped. In this sense, the produced lessons could be tested at least in the German partner school. Moreover, as previously highlighted from the evaluation of the 7 projects, students did understand how AI or/and ML methods were implemented in the framework of each one of the projects, but they could not perceive the core mechanisms lying behind these concepts. From this aspect, these lessons can be valuable for those who want to further explore AI and ML and delve into these core mechanisms.

Figure 9: Piloting Project 0 in German partner school

Regarding the time implementation it is estimated that 28 hours in total are needed in order for all the lessons to be completed. This means that if an educator teaches these lessons 2 or 3 hours per week, then in an interval of 3 months all the included activities will be covered. The lessons were implemented by 40 students, ages from 15 to 17 years old. All the students who participated in these lessons had a background on computer science and programming.

The students faced some difficulties, especially in working out some calculations, but overall, they stated that the lessons were of average difficulty. Regarding the question "In a scale of 1 (very easy) to 5 (very difficult), how easy or difficult was this project", the mean average was equal to 2,65 (*Table 23*). Despite the difficulties, the students did like these lessons. The mean average to the corresponding question was equal to 4,20[11].

	1	2	3	4	5
How did you like this project - In a scale of 1 (not at all) to 5 (a lot) -	0	1	4	**21**	14
How easy or difficult was this project for you - In a scale of 1 (very easy) to 5 (very difficult) -	4	**14**	**14**	8	0

Table 23: Results from students' questionnaires regarding how much they liked the project and how difficult they think it was

[11] 14 students chose 5, 21 chose 4, 4 chose 3 and 1 chose 2

According to teachers the most valuable aspect of this project was that students managed to deepen their understanding of the fundamentals of machine learning. This is reflected in the feedback received by the students through the evaluation forms (i.e., questionnaires). Regarding how comfortable/confident they felt to explain different aspects of AI and ML after the implementation of the lessons, the majority of answers are 'Yes' and/or 'A bit' (*Table 24*). In particular, and regarding explaining what AI is, 22 students replied 'Yes' and 17 'A bit', while 1 answered 'Not at all'. Regarding their feelings towards explaining how AI can be used in real life, 25 students chose 'Yes' as an answer, and 13 'A bit'. Something similar is also reflected in the answers that students gave when they were asked to express how comfortable they were feeling to explain what ML does. Overall, students were more positive towards this aspect. Specifically, 25 chose 'Yes', and 14 'A bit' as an answer. The numbers are a bit different in the question regarding if they were feeling comfortable on experimenting with AI projects, and built and program an AI artefact, since 25 students declared that are feeling 'A bit" confident, 7 of them replied 'Yes', and 8 of them replied 'Not at all'. This finding is probably reasonable since the lessons did not contain any hands-on practice.

After this project I feel comfortable to	Yes	A bit	Not at all	Not applicable
Explain what AI is	**22**	17	1	0
Explain what ML does	**25**	14	1	0
Explain how AI can be used in real life	**25**	13	2	0
Experiment with AI projects, building and programming an AI artefact	7	**25**	8	0

Table 24: Results from students' questionnaires reflecting their attitude towards AI and ML

Additionally, 17 students declared that they might use the gained knowledge and skill in a similar project, while 21 answered that they will definitely use the gained knowledge in the future (*Table 25*). Regarding motivation on learning more about AI, 19 students declared that they have been definitely motivated, 14 declared that they might have been motivated, 3 claimed that they were definitely not being motivated and 4 weren't sure, or didn't know at that point. Again, based also on feedback received by the teachers, these results can be interpreted as a rather positive attitude of the students towards these aspects.

	Definitely Yes	Maybe	Definitely No	Don't know/Not sure
I feel I can use the gained knowledge and skills in new similar projects	**21**	17	0	2
This project has motivated me to learn more about AI	**19**	14	3	4

Table 25: Results from students' questionnaires concerning gained knowledge and motivation

Concerning any future improvement of this project, teachers recorded that there should be more interactivity. More simulations are suggested to be done and there should be more time for students in order to make more experiments.

In general, and according to the evaluation received through questionnaires and through teachers reports, the 18 lessons can be considered as useful resources for those who want to delve into parameters related to AI and ML concepts.

Summing up: reflections and lessons learned

Overall, 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 during the C3 training, a positive attitude towards the entire content of the handbook has been reported.

First of all, the created impression is that the majority of students did like the proposed projects. This is reflected not only by teachers' reports but also by students' responses in the evaluation form. Specifically, in the question "In a scale of 1 (not at all) to 5 (a lot) how did you like this project?" that was posed to students, the mean average was equal or above to 4 for almost all the projects. Project 6 was the most favorite with mean average 4,5 and the next most favorite was Project 2 with mean average equal to 4,30, while the least favorite was Project 5 with mean average equal to 3,84 (*Table 26*).

In a scale of 1 (not at all) to 5 (a lot) how did you like this project?								
	Pr 0	**Pr 1**	**Pr 2**	**Pr 3**	**Pr 4**	**Pr 5**	**Pr 6**	**Pr 7**
5	14	7	28	9	23	8	24	9
4	21	26	20	14	17	13	9	15
3	4	4	7	6	8	8	5	4
2	1	0	2	1	1	1	0	1
1	0	0	0	0	2	1	0	1
Total	**40**	**37**	**57**	**30**	**51**	**31**	**38**	**30**
Average	4,2	4,08	4,30	4,03	4,14	3,84	4,5	4,00

Table 26: All the results from students' questionnaires regarding how much they liked the projects

The difficulty of the proposed projects seems to be appropriate for the age of the participated students. By looking at the results from the students' questionnaire, and in particular on the answers regarding the question "In a scale of 1 (very easy) to 5 (very difficult) how easy or difficult was this project for you", it was noted that the mean average for each project varied from 2,37 (Project 6) to 3,03 (Project 1) (*Table 27*). An interesting fact is that the projects that revolved around the creation of a robotic car (i.e., Project 1 and 2) were those that were perceived as more difficult with a mean average equal to 3. However, as teachers mentioned, despite the mean difficulty and the problems that were faced during the implementation of the projects, students were not discouraged from continuing working on each one of the projects, and their interest was overall kept on a high level.

A significant challenge that was faced, especially during piloting the first two projects (i.e., Projects 1 and 2) was the actual time needed for their implementation. It was proved that in some cases (such as Project 1 and 2) the initial time plan was not adequate. Teachers needed to spend more time on preparation and teaching in order to smoothly introduce students both to the technologies that were used (i.e., Arduino board and Raspberry Pi) and the AI services and programming tools, but also to some fundamental AI and ML related concepts. This introductory phase was necessary also due to the fact that the majority of the students had no previous experience on working with these particular hardware and software. As a result, in the aforementioned cases, the actual time of implementation was three or four times more than the estimated one. According to teachers reports this problem could be tackled if some easier projects, such as Projects 5, 6 and 7, had been implemented prior to Projects 1 and 2. Therefore, it was decided to add to the handbook some cross references among the projects, suggesting to teachers to start with easier projects included in the handbook, in case their students have no previous experience on the proposed hardware and software. These cross references are added as an extra section at the end of each project under the title “Tips and Recommendations”. In this section, a number of tips highlighted as good practices, after the evaluation of each project, are also included. Another idea that was suggested was to add notifications concerning the level of difficulty of each one of the included projects (e.g., Project 1 can be referred as a project of intermediate difficulty, while Project 5 can be characterized as an easy one).

In a scale of 1 (very easy) to 5 (very difficult) how easy or difficult was this project for you?								
	Pr 0	**Pr 1**	**Pr 2**	**Pr 3**	**Pr 4**	**Pr 5**	**Pr 6**	**Pr 7**
1	4	0	4	3	10	5	14	2
2	14	9	15	7	8	8	4	6
3	14	18	21	18	26	13	14	16
4	8	10	13	2	5	4	4	5
5	0	0	4	0	2	1	2	1
Total	**40**	**37**	**57**	**30**	**51**	**31**	**38**	**30**
Average	2,65	3,03	2,96	2,63	2,63	2,61	2,37	2,90

Table 27: All the Results from students’ questionnaires regarding the difficulty of the projects

Regarding AI and ML concepts, and how they were perceived by students after the implementation of the projects, it was noted that the majority of them felt - at least - a bit confident on explaining what these fields are about and how they can be used in real life, but still they were not feeling fully confident towards these concepts. After having closely observed the entire process, teachers argued that this lack of self-confidence is not related to the content of the proposed projects but to the fact that students could not fully understand the mechanisms laying behind these concepts. According to them, and after having implemented all the aforementioned projects, they supported that a longer introductory course to AI (such as the lessons included to Project 0) would probably lead to an easier understanding of the immanent concepts. For this reason, cross references to lessons included in Project 0 are also considered to be incorporated to the handbook.

Based on the outcomes concerning their motivation on learning more about AI, it can be argued that projects such those included in the handbook can encourage students on further exploring the aforementioned fields thus leading to developing a positive attitude towards these concepts. Another interesting finding is that in cases in which hands-on activities were involved, the majority of students stated that they are feeling rather comfortable experimenting with AI projects as well as building and programming an AI artefact, leading to the assumption that coupling AI and ML concepts with making activities and practices can boost students' confidence towards learning by doing. In this sense, the content of the included projects can be considered appropriate for smoothly introducing students to all the aforementioned new concepts, methods and technologies.

The produced OERs (teacher's guidelines and students' worksheets) for supporting the implementation of each one of the projects had a significant role in the rather smooth introduction and implementation of the majority of the projects. According to the teachers' report the aforementioned resources helped them towards the planning and the implementation of the project. This statement is partially reflected on the responses received by the students, who in the majority did find the worksheets useful. As it is presented in Table 28, and concerning the question "In a scale of 1 (not useful) to 5 (very useful) how useful did you find the student worksheet), the mean average is above 3, indicating that most of the students did found helpful the worksheets, at least to a certain extent.

In a scale of 1 (not useful) to 5 (very useful) how useful did you find the student worksheet?								
	Pr 0	**Pr 1**	**Pr 2**	**Pr 3**	**Pr 4**	**Pr 5**	**Pr 6**	**Pr 7**
1	0	0	1	0	1	5	0	3
2	2	1	3	7	1	6	0	1
3	14	14	15	8	12	13	6	12
4	16	16	17	15	23	4	16	10
5	8	6	21	0	14	3	16	4
Total	**40**	**37**	**57**	**30**	**51**	**31**	**38**	**30**
Average	3,75	3,73	3,95	3,27	3,94	3	4,26	3,37

Table 28: All the results from students' questionnaires regarding the usefulness of the worksheets

Finally, regarding the content of the projects, another significant aspect that was highlighted by teachers was the fact that such projects (i.e., projects that are engaging students in real-world scenarios and problems, as well as in hands-on practices) can function as opportunities for expanding the current curriculum with new technologies, thus widening the boundaries of traditional educational methods. Such project-based educational practices, combined with AI methods and technologies can lead not only to the familiarization of students with fundamental mechanisms of AI and ML, but they can also help them gaining critical skills (such as communication, problem solving and collaboration), thus being prepared for the future labor market which is expected to be significantly disrupted from the AI.

Extra resources:

Guidelines for an extension of Project 1: The Robotic Car recognizes Traffic Signs

Some of the problems that emerged during the piloting phase (and still exist) was the lack of the available electronic components in the market, as well as the raising of prices of some boards (i.e., raspberry pi board) which drastically altered the total budget of some projects. Due to this fact, and based on discussions regarding creating a handbook in which the more demanding projects will build upon the easier one, an extra project is proposed which functions as an extension of Project 1, and as an alternative solution of Project 2.

The extended scenario combines the (Arduino-based) DIY robotic car and the application that were created and designed for the needs of Project 1, with the AI methods of image classification and image recognition in order to create a semi-autonomous vehicle that is able to recognize traffic signs and act accordingly. Therefore, the contained guidelines build upon Project 1, while fostering a number of modifications towards the realization of this alternative solution.

Apart from Arduino IDE programming environment and MIT App Inventor software that are used for the implementation of the specific scenario, the environment of “Personal Image Classifier” is introduced. Through this environment, the students will be able to train a model that will classify images depicting specific traffic signs (such as deadlock, turn left, turn right and stop). Then, they will learn how to properly integrate this model to a modified version of the application designed for the needs of Project 1. This modified version will be able to instruct the robotic car to perform specific movements based on the results of the image classification. For this reason, a number of modifications on the Arduino IDE code will also be done, giving the opportunity to students to delve into more advanced programming concepts such as the functions and the routines.

To make this project work properly, the students should also reflect upon the model of the robotic car since they need to find ways to embed the smart device on the car’s chassis, and in such a way that will enable the robotic car viewing the traffic signs, through the embedded camera.

The estimated time of implementation of this extended scenario is about 10 hours divided in 5 sessions. At least one session should be devoted to the image classification training phase and the testing of the model not only through the Personal Image Classifier environment, but also through the application designed in App Inventor. Based on this, a number of advantages and risks of using image classification for creating a semi-autonomous car can also be stressed and discussed. Another session can be dedicated to the needed modifications of the application and to the necessity of using tuples and probabilities in order to create a more reliable semi-autonomous car, as far as the embedded image recognition system is concerned. The modified Arduino IDE script and the more advanced programming concepts (i.e., functions and routines), as well as the reflections on the construction of the DIY car to better embed the smart device, can be addressed in the rest sessions. The actual time of implementation can vary based on the available class time and the students’ level. The same applies for the necessity of introducing in depth all the aforementioned steps and concepts (i.e., tuples, probabilities, functions, routines etc.).

The guidelines for the extended scenario can be found here.

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