Introducing Artificial Intelligence in school education: the Edu4AI project

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Abstract

This paper focuses on the "Edu4AI handbook", an educational handbook produced in the framework of the Edu4AI (Artificial Intelligence and Machine Learning to foster 21st century Skills in secondary education) Erasmus+ project, which revolves around the proper integration of AI in education through the lens of pedagogies and methodologies inspired by the Maker Movement trend and project-based learning practices. The Edu4AI handbook contains eight interdisciplinary AI projects developed by the Edu4AI partnership, which were piloted and evaluated by the partner schools, leading to fruitful thoughts and reflections as far as the incorporation of AI and ML to school education is concerned. To set an example of the aforementioned AI projects, the "Device that turns sounds to visual signs" project and the corresponding findings of the evaluation are presented and analysed, initiating a dialogue regarding the educational value of such learning interventions.

Keywords: Edu4AI, Artificial Intelligence, Machine Learning, Sound classification, Project-based learning, Arduino-based project

Résumé

Cet article porte sur le «Edu4AI Handbook», un manuel pédagogique réalisé dans le cadre du projet Erasmus+ Edu4AI, qui s'articule autour de la propre intégration de l'IA dans l'éducation à travers de pédagogies et de méthodologies qui s'inspirent de la tendance Maker Movement et de la Pédagogie de projet. Le manuel Edu4AI comprend huit projets d'IA interdisciplinaires développés par les partenaires constituant le partenariat Edu4AI, qui ont été pilotés et évalués par les écoles partenaires, conduisant à des réflexions fructueuses en ce qui concerne l'intégration de l'IA et de l' Apprentissage automatique (ML) dans l' éducation scolaire. Pour donner un exemple des projets d'IA susmentionnés, le projet "Appareil qui transforme les sons en signes visuels" et les résultats correspondants de l'évaluation sont sélectionnés pour être exposés et analysés plus en détail, initiant un dialogue sur la valeur éducative de ces interventions d' étude.

Mots-clés: Edu4AI, Intelligence artificielle, Apprentissage automatique, Classement sonore, Pédagogie de projet, projet basé sur Arduino

Introduction

During recent years Artificial Intelligence (AI) has become a significant part of our life. Without being aware, we are constantly – and on a daily basis - interacting with AI technologies and systems. This rapid and vast integration of AI leads to radical transformations of many disciplines, including education and paths of future careers, and consequently to an imperative need for acquisition of new skills (Taguma et al., 2018; Tuomi, 2018). The importance of the introduction of AI in education has been emphasized by UNESCO as having an enormous potential for the social good and for the achievement of the social development goals (UNESCO, 2021). Regarding school education, the transformation seems to be two-folded. While a number of STEM related practices, including AI & ML are slowly being introduced to the school curriculum or to learning activities that are taking place during extracurricular hours, there is a wide discussion for a paradigm shift that can foster and consequently lead to the acquisition of 21st century skills, such as communication, creativity, critical thinking, collaboration and problem solving (Alimisis, 2020; Tuomi 2020). The latter is also raised from concerns regarding the proper integration of AI in education and several immanent risks and challenges. Even though it is crucial for students to be educated towards the emerging AI & ML technologies, it is equally important neither to perceive them as necessarily future professionals in computer science nor as passive consumers of existing AI techniques and services, but to develop (through learning and using AI & ML) essential skills for life.

Nowadays, there is a wide variety of AI and ML (Machine Learning) technologies that could be selected for supporting students' learning in these fields (Kahn 2018; Touretzky et al., 2019). Through several online tools, students can become familiar with basic/fundamental mechanisms of AI and ML, understand how they work, and build some relevant experience. AI tools are already implemented in many parts of the educational process including content development, teaching methods, student assessment, and communication between teacher and students (Chassignol 2018). However, this knowledge and the concepts laying underneath, remain rather abstract, if students' work is limited to a virtual (computer-based) and abstract form. The suggested focus in K-12 education for students mainly concentrates across three dimensions: AI concepts, AI applications and AI ethics/safety (Wong, 2020). Students, especially younger ones, have however difficulties in fully grasping abstract AI concepts, if they don't apply them in real-life settings through tangible experiences and concrete methods. Therefore, it is important that learning AI and ML provides an authentic connection to students' everyday life through real world problems and/or challenges, and through multisensory experiences.

In this sense, it is argued that learning AI, if coupled with methodologies that draw upon the Maker Movement trend and project-based learning practices (Blinkstein 2013, 2018), should be used as a means and a channel for initiating and establishing a fruitful dialogue with contemporary inclusive educational practices. With this as a solid background, the Edu4AI (Artificial Intelligence and Machine Learning to foster 21st century Skills in secondary education) Erasmus+ project (www.edu4ai.eu), aims at developing practices that can lead to a smooth and meaningful incorporation of AI and ML practices into the school curriculum, and especially through the lens of project-based learning methods that can introduce AI and ML in a playful and hands-on way.

Through the implementation of tangible AI experiences – and in the framework of the Edu4AI project – a handbook including eight interdisciplinary projects, revolving around the field of AI and ML, was produced. 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, and stress out practices and methods that involve computer-based learning with creative hands-on experiences, while revolving around the acquisition of the 21st century skills. Moreover, the handbook is enhanced with relevant Open Educational Resources (OERs) for both educators and students, such as teacher's guidelines, students' worksheets and videos, functioning as means for better communicating the scope of these projects, while emphasizing on building skills that will enable/establish a meaningful dialogue between learners and technology.

This paper presents in detail the *"Device that turns sounds to visual signs"* project as a representative example of the eight developed projects. The 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.) and it was piloted in partner schools providing valuable feedback from both teachers and students who evaluated it after its implementation. Therefore, after the description of the project, the findings of the evaluation are presented and analysed leading to some fruitful thoughts and reflections.

The framework of the Edu4AI project

The Edu4AI project aimed at bringing together AI-enhanced apps and artefact construction through a methodology that draws upon the Maker Movement trend in education and project-based practices that can be applied in the class. The pilot studies have been carried out in schools in Germany, Greece, Italy and Spain. The five core phases of the project included: the technical design, the pedagogical design, the teacher training, the pilot studies with students and teachers in the four countries and the documentation of the good practices. After 2 years of concept design, deployment and implementation of the pilot projects, the feedback of all participating organizations, as well as of the teachers and students who have participated, has been gathered and assessed. Based on this evaluation and on the specifications produced in advance, a detailed description of the curricula and all the activities has been produced.

The Edu4AI handbook

The Edu4AI handbook has been produced in the framework of the Edu4AI Erasmus+ project, and contains eight projects related to the field of AI and ML. These eight projects were developed by the partners, constituting the EDU4AI partnership, and were piloted by the partner schools in four different countries (i.e., German, Greece, Italy, and Spain). They were designed with the goal to present a variety of AI-enhanced apps and intelligent artefacts by implementing different AI-related services, technologies and tools. Apart from the eight projects, the handbook also includes a number of lessons aiming to familiarize educators and students with fundamental concepts and mechanisms of AI and ML.

The content of each project was decided in collaboration with all partners. In particular, the partners (including the partner schools) were asked to express and share their thoughts and ideas orally (during a training meeting held online in March 2021), as well as in written form through a provided template. In this template the partners were encouraged to provide a short description of their proposed project and list the technologies and tools that would support their ideas. This process would also facilitate a better categorization of the proposed projects, through the lens of the different AI services (i.e., voice recognition, printed text recognition, text to speech, image classification, emotion recognition, chatbots, Programmable AI Toys) that were proposed. From this process 23 different scenarios and ideas in total were collected, leading to the selection of the eight projects covering different aspects of AI in education. Pluralism and the age appropriateness of tools and AI services required for the implementation of the projects, as well as having activities that would be in line with the pedagogical considerations and methods (that were highlighted earlier) were some of the main criteria of this selection.

The eight projects were further developed based on a new template. Based on this, each project should contain a) a scenario inspired by real life, b) 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, c) information about the learning, the hardware and software prerequisites, d) a time plan with an estimated duration of each project, as well as e) a number of related OERs targeting both teachers and students (i.e., teacher's guidelines with pedagogical tips and considerations, as well as programming and implementation solutions, students' worksheets with tasks and activities for easing the implementation of the projects, and evaluation tools for gathering feedback by the participant students and teachers) which were provided as external files.

The projects were piloted in the partner schools. After the implementation of each project, both teachers

and students filled an online evaluation form providing valuable feedback regarding the implementation of these learning interventions, through the documentation of their experiences. Additionally, a number of reflections and considerations were recorded during a live discussion with teachers who piloted the projects (held in the framework of a meeting in July 2022), leading to lessons learned and the final refinement of the handbook.

The “device that turns sounds to visual signs” project

About the project: scenario and steps towards realization

This project revolves around sound recognition and audio classification methods coupled with hands-on practices, and it is oriented towards the creation of 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 is an Arduino-based electronic artefact equipped with a Bluetooth module and a number of LED lights, of different colors. Each one of the LED lights represents a different category of sounds (e.g., the orange light can represent doorbell sounds, the red light can represent alarm sounds etc.). The device receives data from an application designed in MIT App Inventor software. The application records sounds, classifies them (by using a trained model) and based on the result of the classification, instructs the Arduino-based device to blink the corresponding LED light (e.g., if the recorded sound is classified as an alarm sound, then the red light will blink). To do so, classification of different sounds needs to be developed. This classification is made through the Personal Audio Classifier training environment; an application that produces trained models compatible with the MIT App Inventor. The trained model is then embedded on the designed application, enabling the classification of the recorded sounds.

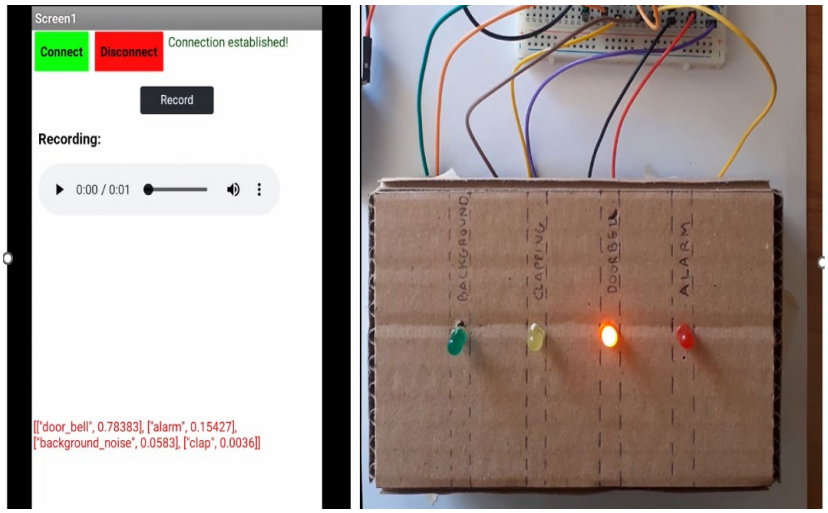

Figure 1. *Left : Image of the application after an incoming sound has been classified ; Right : Image of the electronic device that blinks the light corresponding to the classified sound*

Therefore, and in the context of this project, the students are invited to a) create and program the electronic device, b) create a taxonomy of sounds by recording and classifying them to different categories, and c) develop an application that will establish the communication between the physical environment and the electronic device, by enabling user to record environmental sounds. To make this happen, they need to work in teams and pass through a number of stages, such as brainstorming, exchanging of ideas, planning, creating, experimenting, testing and sharing. In this way, the students are engaged in a real-world problem, and are encouraged to find solutions by exploring different aspects of the problem through the implementation of different technologies and hands-on practices.

Learning objectives of the project

It is argued that through this project students will be able to discuss different aspects of using AI for helping a specific group of people (i.e., people with hearing loss) and explain basic concepts regarding the audio classification process. They will also be able to identify and discuss advantages and immanent risks of audio classification, as well as to explain basic concepts regarding turning an audible information to a visual one.

Moreover, students will learn to construct an electronic artefact and create electrical circuits as part of a programmable electronic device, as well as using programming commands coupled with AI methods to address a specific behavior to an electronic device. Additionally, they will learn to classify different sounds based on specific criteria and train a model based on the created classification. They will also learn to reflect their ideas through programming and exchange ideas and views in teams regarding emerging challenges.

It is also expected that students will develop self-confidence in applying AI programming methods, and especially those related to audio classification technology, while setting a plan for overcoming problems and challenges. Moreover, it is expected that students will learn how to collaborate, and find solutions on the emerging problems as a team by forming new ideas and making recommendations, while valuing the risks of using AI technologies. Finally, they will be able to develop strategies that will reduce inequalities by providing solutions for people with hearing loss regarding their daily life in a domestic environment, while they will learn to promote innovative solutions and new ideas regarding domestic systems.

Learning prerequisites and time plan

As mentioned, an Arduino board equipped with a Bluetooth module and some LED lights, as well as a number of easy-to-use materials that will enable modelling the electronic device, are needed for the implementation of this project. A smart device (smartphone or tablet) is also necessary to install the created application.

Concerning software, Arduino IDE environment (https://www.arduino.cc/en/software) is needed for programming the electronic device, and MIT App Inventor (https://appinventor.mit.edu/) for creating and programming the application. Personal Audio Classifier environment (https://c1.appinventor.mit.edu/) is also needed for producing the trained model. Additionally, mBlock block-based programming environment (https://mblock.makeblock.com/en-us) is suggested for familiarizing students with programming and for a smooth transition from block-based to text-based coding.

As far as learning prerequisites are concerned, even though the provided OERs can fully support the implementation of the project without any previous experience, it is highly recommended that the students should be familiar with block-based coding and the Arduino IDE environment. Some good practices for introducing Arduino IDE coding to students are also included in the handbook.

Concerning the time plan, the project was estimated to be completed in 6 hours, divided in 3 sessions (i.e., 2 hours per session). Specifically, it was estimated that students will be able to complete the electronic device (circuitry and programming) within 2 hours (1st session). Then, they would need approximately 1 hour for creating a model (paper model or 3D model) to embed the circuit of the device, and 1 more hour for training the model that will be able to classify the sounds (2nd session). After that, they would need 2 more hours in total (3rd session) to create and program the application that will record the sounds and – based on the result – instruct the device to blink the corresponding LED light. This time plan was suggestive and it was noted that based on students' level as well as the available class time, rescheduling could be considered.

All the aforementioned steps were intended to be performed in teams of 3 or 4 students. To ease the process, students' worksheets would be provided in each one of these teams, while teachers would move around, assisting them or giving tips whenever it was necessary.

Piloting phase: evaluation results and feedback received from the participants

The *"Device that turns audio to visual signs"* project was implemented by 30 students, ages from 15 to 18 years old, in three different countries (i.e., Germany, Greece and Spain). Due to Covid19 restrictions, the implementation was made in teams of 2 or 3 students, who shared the tasks. The students who implemented this project have some experience with programming as well as with Arduino technology (due to the implementation of previous projects revolving around Arduino technology). 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 Personal Audio Classifier. Another significant problem was that the aforementioned tool (i.e., Personal Audio Classifier) proved to be unstable if too many samples are recorded, leading to loss of data, repetition of the process and therefore to probable frustration. To tackle this latter problem, students were encouraged to create less categories of classified sounds, or to record less samples per category than the suggested number included in the guidelines (i.e., 12 samples per category). There were also some minor difficulties with crafting but in general the problems were less than those faced during other projects, implemented on an earlier stage of the Edu4AI project. Due to the aforementioned difficulties, 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 some other projects (also contained in the handbook) did. This is also reflected by the answers that students gave to the corresponding question asking how easy or difficult this project was for you, on a scale of 1 (very easy) to 5 (very difficult). With a mean average equal to 2,90, this project seems to be considered as the third most difficult project, from those contained in the handbook (Table 1).

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 this project was integrated in a larger one (Domotics) related to the creation of a *"smart"* house, thus emphasizing on aspects related to project interconnectivity and interdisciplinarity. Teachers' report is verified by the findings of the students' questionnaire. Regarding the question if students did like this project – and on a scale of 1 (not at all) to 5 (a lot) - the mean average was equal to 4, indicating that the majority of students did like this project (Table 1).

	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 1. *results from students' questionnaire*

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 current curriculum with new technologies. However, it was reported that students did understand how the specific AI technology works but they couldn't understand the core mechanisms laying behind AI and ML.

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 and AI artefact	10	17	1	2

Table 2. *results from students' questionnaire reflecting their attitude towards 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, a positive attitude was recorded. In particular, and regarding explaining what AI is, 16 students replied 'Yes' and 13 'A bit'. Regarding their feelings towards explaining how AI can be used in real life, 15 students answered 'Yes', and 13 'A bit' (Table 2). 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. Regarding how comfortable they were feeling about 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', 1 *"Not at all"* and 2 "Not applicable'.

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"*. 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 (Table 3).

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

Regarding the produced material aimed 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 to plan and implement 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. Specifically, in the question *"In a scale of 1 (not useful) to 5 (very useful) how useful did you find the student worksheet"* the mean average was equal to 3,37, with, 3 students choosing 1, 1 choosing 2, 12 choosing 3, 10 choosing 4 and 4 choosing 5 as an answer.

Discussion

Overall, and based on the feedback received through the evaluation forms (i.e., questionnaires) by both teachers and students, as well as through the experiences that were shared by teachers, the *"Device that turns sounds to visual signs"* was a project that students really enjoyed and found interesting to work on, even though it was perceived as one of the most difficult projects included in the handbook, and despite the problems they faced during the implementation, especially with the training environment (i.e., Personal Audio Classifier). 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 Arduino-based circuitry easier was also included in the suggestions for improvement. Indeed, using shields offers many advantages since it leads to fewer errors than the process of connecting the separated parts and offers an easy way to add new features to an Arduino-like board that otherwise would be difficult to create (Alimisis, 2021).

The fact that the project is based on a scenario inspired from real life, made the entire process more engaging for students and managed to keep their interest at a high level. This was reinforced by the

fact that the project was not emphasized only on how AI services (i.e., sound recognition and audio classification) can be used, but also on how these services can be combined with hands-on practices and experiences such as crafting and programming. Another aspect that was stressed was that, after a while, students managed to smoothly collaborate towards the successful implementation of the project, and they even were assisting other teams in case they were finishing their tasks earlier.

Studying the impact of this project regarding how AI and ML concepts were perceived by the students, it was noted that they felt a bit confident on explaining what these fields are about and how they can be used in real life, but still (and even though some of the students have previously been involved in similar projects) 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 this specific project but to the fact that students could not fully understand the mechanisms laying behind these concepts. According to teachers, and after having implemented not only this but also other projects included in the handbook, they argue that a longer introductory course to AI would probably lead to an easier understanding of the immanent concepts. Also, based on the outcomes regarding their motivation on learning more about AI, it can be argued that projects such as the *"Device that turns sounds to visual signs"* can encourage students on further exploring these fields thus leading to developing a more positive attitude towards these concepts. Additionally, the content of this particular project is considered appropriate for smoothly introducing students to all the aforementioned new concepts, methods and technologies.

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 enriching 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 to an initiation and an establishment of a meaningful dialogos between learners and new technologies since they are not only tending to familiarize students with fundamental mechanisms of AI and ML, but they are targeting on helping students gaining critical skills (such as communication, problem solving and collaboration), thus preparing them for the future labor market which is expected to be significantly disrupted from the AI innovation.

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