Fostering Awareness and Personalization of Learning Artificial Intelligence

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Abstract

This paper illustrates the activities of the projects SMAILE and AILEAP, which are devoted to foster the growth of awareness and readyness to learn artificial intelligence in the general population. The first project was mainly oriented to children and young adults, while the second is more oriented to the personalization of the learning experience also in professionals.

Keywords

Artificial Intelligence, Learning, Personalization, Awareness of Technology

1. Introduction

The new digital society, in which artificial intelligence (AI) and autonomous systems play an increasingly important role, will require all citizens to develop a solid foundation of digital skills. A good level of digital awareness and skills will enable citizens to actively participate in the new digital world, access public services, find a job, and avoid the digital divide, which will be one of the main reasons for poverty in the future.

In "Digitalization, Al and Equity – How to strengthen the EU in the global race of future skills and education, while ensuring social inclusion", the European Economic and Social Committee stresses that "skills and competences play a key role in ensuring the EU's success in global competition with respect to digitalization and AI. There is a need for society as a whole to be equipped with the necessary understanding, knowledge, and skills for the 'AI era', so as to make full use of the overall potential and to keep everyone on board." Additionally, the recommendation of the Commissioner for Human Rights on Artificial Intelligence "Unboxing artificial intelligence: 10 steps to protect human rights", underlines the importance of investing in the literacy on AI of the general public through robust awareness raising, training, and education efforts. Moreover, AI is already under examination as part of the ongoing update to DigComp: the European Digital Competence Framework. Looking at the Digital Economy and Society Index (DESI, https://digital-strategy.ec.europa.eu/en/policies/desi), the Italian initial situation is quite critical. We urgently need to develop innovative solutions to address the lack of digital skills.

In order to make more effective the teaching of the fundamental concepts of AI to the broad public, it is useful to adapt the contents, the learning environment, and the approach to the learners. This process requires identifying as accurately as possible how learners differ from one another in abilities involved in the specific learning domain and, then, making decisions about how to design personalized learning experiences. Specifically, the projects SMaILE (http://www.smaile.it/) and AI-LEAP (http://www.ai-leap.it/) aim at fostering the personaliza-

Ital-IA 2023: 3rd National Conference on Artificial Intelligence, organized by CINI, May 29–31, 2023, Pisa, Italy

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CEUR Workshop Proceedings (CEUR-WS.org)

Figure 1: Playful activities performed with children.

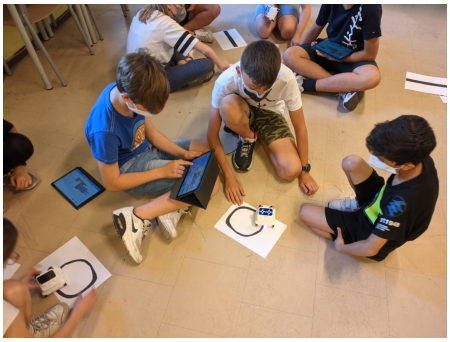

Figure 2: An AI coding lesson.

tion of the learning experience along three different lines.

Learning of AI: we claim that the understanding of AI is improved by the development of basic natural abilities that individuals master to varying degrees. Early recognition of each child's different mastery of abilities enables a personalized training aimed at strengthening the identified weaknesses.

Embodied AI: AI is often applied to or associated with physical devices, like robots. The production of specific learning materials that can be flexibly be composed in a personalized learning experience, to be tailored to each individual's mastery of specific abilities, is a still open field.

AI as a tool to personalize learning: AI representations and reasoning allow the construction of powerful tools to personalize teaching non-IT professionals. In particular, we will study the case of physicians.

2. SMaILE

At the time of writing, the project is still on-going (ending in December 2023). The authors are involved in the subproject EmpAI (empowering artificial intelligence). We briefly describe the activities and results achieved so far, see [1, 2] for more details.

First, we developed a set of unplugged activities for training basic abilities that learners already have and that we devise as at the basis of acquiring mastery of symbolic AI. We also investigated, in collaboration with Quercetti (http://www.quercetti.it/), the use of educational toys for acquiring skills in AI.

Concerning the first task, the identified abilities that we wish to strengthen are: (i) ability to differentiate between syntax and semantics; (ii) ability to classify data; (iii) ability to behave based no test-operate-test-exit unit; (iv) ability to plan.

For each such ability, we designed training activities as playful practice tasks for children (see Figure 1); each activity was followed by a reflection phase in which children were asked to summarize the activity they performed, reflect on it in order to understand the principles of the task they were asked to perform, and, finally, to generalize the principles by finding similar everyday life situations. For instance, in order to strengthen the ability to differentiate Between Syntax and Semantics, we developed the "Egyptian Room". Inspired by Searle's Chinese room, this activity consists of six rounds. At each round, one child is selected to sit at the knowledge desk: a desk which will give him or her the power to quickly associate hieroglyphic answers (output) to hieroglyphic questions. This is made possible by providing the child at the desk with the right correspondences. The child has to just pick the paper string associated with the one amounting to the question and give it to the expert. Afterwards, children in the class are asked to answer the same hieroglyphic question. To do so, they will have, first, to translate symbols in letters, then letter strings into Italian words. Finally, they will select a possible answer from a s et of possible answers. More than one answer is possible, so each of them is collected by the expert at the blackboard.

We involved a group of schools, that are located in the city of Torino, in the experiments. Six classes belong to the fifth grade while six classes belong to the sixth grade. Half of them (three fifth grade and three sixth grade classes) the training and half were part of the control group. The control group carried out activities that were similar to the training ones in terms of used material and topic, but that do not train the abilities we are interested in. To assess the success of our training, we will perform a test before the training/control session, and the same test was performed at the end of the AI coding lessons (see Figure 2).

Quercetti, in collaboration with the University of Torino, designed some unplugged activities to introduce the AI concepts (symbolic manipulation, non symbolic manipulation and machine learning, and planning)

Figure 3: Enigma by Quercetti.

to children by means of games produced by Quercetti. The activities proposed to primary schools tackle topics among which are the following:

- the transduction problem, that is to translate real problems into programs. The activity introduces repetition/iteration concepts.
- problem solving. This activity introduces students to the notion of "state of affairs" as a set of properties that hold in a certain moment, the "state of affairs" as a goal to achieve and the notion of solution as a set of steps, organized into an execution path, that allows to reach the desired state of affairs in the best way possible.
- cryptography, and the concepts of encoding and decoding information. The aim is to underline the importance of having strong encryption that can withstand a brute force attack.

Many Quercetti games were used, among which "Pallino Coding" and "Tag the Picture". One, Enigma (see Figure 3), was partially designed and developed from scratch within the project.

All the teaching materials produced along the project have been organized in a web site (https://empai.di.unito.it/), that includes a number of online courses in order to allow the interested teachers to download and use the material in a profitable way. The site is structured intto the following parts: Coding, Unplugged Activities, Discussion and Q&A space, Training for teachers. The Coding section collects eight lessons that we developed to explain the basic concepts of programming (in the first four lessons) and of Codey Rocky programming (in the remaining four). For each lesson one can find a) a video of duration up to 10 minutes meant to serve as a teacher guide. Here, one of the instructors who performed the activity in class explains the objective of the lesson, the main parts in which it is structured and the main concepts which are explained; b) a pdf file meant to serve as a teacher guide as well. One the one hand it presents the information in a different format (which could be more suitable to bring in class when actually performing the activity) and, on the other hand, it provides a higher level of detail; c) the slides of the lesson to be presented to learners and used as a guide. We decided to supply the pptx format so that lessons could be changed by teachers to tailor them to their needs.

The unplugged activities are grouped in two main categories concerning Artificial Intelligence and Computer Science concepts. The characteristic of this type of activities is that they do not require the use of technological devices but they require the preparation of paper-based material. Accordingly, we provide a teacher guide for each activity describing, in the first part, the aim of the activity, the concepts that are addressed, the list of the material needed and the competences and skills that the learners will acquire in performing the activity. After this introductory part, the activity is described in detail in a way that it can be replicated. Accordingly, both the instructions on how to prepare the material and the discussion that the teacher should undertake are reported. The material to print is provided as additional files.

We set up a space that is meant to support several types of interaction between the research group and teachers or other interested users accessing the website. This area is managed as a forum where few threads (on coding and on the unplugged activities) are already available and others can be added. The idea is to leverage on the interdisciplinary nature of the research team, to support teachers in their activities in class. In this way, both questions, curiosities and new ideas can be discussed both from the computer science and the educational points of view. Moreover, in this area we aim at collecting feedback of any kind on the material that we developed. This will be a precious source of ideas and suggestions to improve the course. Interestingly, forums are visible to every user registered to the website so that interactions can occur even among users who can exchange ideas and suggestions on how to perform the course.

Training for teachers was developed in collaboration with the crowdfunded project"Impa.IA.mo l'Intelligenza Artificiale Giocando" (https://www.ideaginger.it/progetti/impar-ia-mo-l-intelligenza-artificiale-giocando.html). We believe that to fully benefit from the course we are proposing, it is important to understand the main concepts underlying it. To this aim we conceived a course for teachers consisting of three lessons. In the first one we explain the main concepts of Artificial Intelligence (AI), what AI is and what is not and what is the difference between strong and weak AI. In the second lesson we introduce and explain the four basic cognitive abilities that are the target of the proposed unplugged activities and that are involved in the AI concepts that we consider in this project. Finally, the

third lesson explains the main programming concepts that we address in our coding course and how they are addressed and explained in the course. For each of these three parts we provide a video and a set of slides. Additionally, we designed a self-evaluation quiz which is meant to be a tool that a user can use to identify the main take-aways of the corresponding lesson and whether she/he grasped the important parts of it.

3. AI-LEAP

This project continues the experience of SMaILE but it is more strongly focused on personalization. Personalization is critical to developing methods and techniques that democratize design, innovation, and knowledge creation, and make citizens aware and active members of society. Personalization targets, in the case of AI-LEAP, the learning of AI. This choice is motivated by the desire of supporting the complex process of construction/interpretation of the AI-permeated world, which requires the construction of the right conceptual tools in the people and in the society: "AI is a question of culture" [3] but culture is more easily spread when it is tailored to the individual. Moreover, AI-LEAP investigates also AI as a tool for personalizing the learning experience concerning topics that ar far from AI.

It is organized in three sub-projects, namely: T3-AI (Personalizing Test to Tailor Training of AI), under the responsibility of the principal investigator (UNITO); Teach E-AI 2C (Teaching Embodied Artificial Intelligence to Children), under the responsibility of Progetto Partner Ricerca e Sviluppo 1 (NAC-UNINA, with Treccani Futura and Città della Scienza as "partner territoriali"); PTPC-AI (Personalized Training of Professional Competencies with AI), Progetto Partner Ricerca e Sviluppo 2 (AI@UPO, with DAIRI and POP-AI as "partner territoriali").

T3-AI will investigate how early identification of each child's differential mastery of foundational cognitive capabilities involved in machine learning, probabilistic AI, and symbolic AI allows for a personalized training that strengthens the individual weaknesses. For what concerns symbolic AI the project will exploit as a base the results from the project EmpAI@SMAILE. Teach E-AI 2Caims at creating specific learning materials that can be assembled into a personalized learning experience tailored to the individual's mastery of specific skills. The sub-project is based on instructional design principles and the 4C/ ID model. Adopting an Embodied AI approach leads to: 1) overcoming a strictly algorithm-driven approach, 2) understanding how biological systems work to replicate them in artificial systems, 3) developing principles for intelligent behavior and 4) applying these principles to artificial systems that interact with the real physical world: robots. PTPC-AI is based on the assumption that the personalization that can be achieved through the use of AI representations and reasoning is key to effective and tailored training for professionals who are not IT, such as physicians.

3.1. T3-AI

Learning of AI will explore the basic cognitive capabilities for machine learning and probabilistic AI approaches. Early identification of each child's differential mastery of abilities allows for personalized training aimed at strengthening identified weaknesses. In recent years, we have explored the idea that it is possible to identify "basic abilities" that are already present in humans and that, when trained, favor learning of symbolic AI approaches [1, 2]. In this context we identify the following main goals: Given the importance of dataset construction to machine learning and probabilistic AI approaches, the project will focus on the basic abilities that underlie it. The child-as-data-analyst metaphor captures the finding that even infants are remarkably sensitive to statistical regularities in the environment and use these regularities in forming categories [4]); the child-as theorist metaphor captures the observation that children's concepts go beyond obvious or perceptible features to include theory-rich entities such as causes, functions, teleology, and essences in their concepts [5]. The ability to think about the possible/impossible instances of a given category is an example of a basic ability children need in constructing data sets. We will engage primary and secondary school teachers in educational events aimed at increasing the culture of AI and explaining the fundamentals for training the basic abilities of their students.

- Goal 1: Facilitate learning of machine learning and probabilistic AI approaches by training basic abilities that are innate to children. The ability to think about the possible/impossible instances of a given category is an example of a basic ability children need in constructing data sets.
- Goal 2: To develop a tool to assess each child's developmental level of the basic abilities required to learn AI. Such an assessment would allow personalized training sessions to be developed to improve AI learning.
- Goal 3: With the support of Treccani Futura and of POP-AI, dissemination of the results of the research, the practices and tools in the school world.

3.2. Teach E-AI 2C

Embodied AI aims at creating specific learning materials that can be assembled into a personalized learning experience tailored to an individual's mastery of specific

skills. Specifically, the goal is to understand how biological systems work in order to replicate them in artificial systems, develop principles for intelligent behavior, and apply these principles to artificial systems that interact with the real physical world: robots. In this context we identify the following goals: Developing an integrated platform aimed at children and adolescents, by implementing a robotic farm, an integrated hardware/software system for evolutionary and interactive robotics. This platform will be implemented in such a way that it can be easily used by kids so that they can see E-AI basics and concepts in action and practice them hands-on. In this challenge, implementing a solid and effective system is essential to ensure usability. Engaging a broad audience and allowing kids to use the learning units and perform tasks in a simulated and physical environment to practice with Embodied AI. Learners will have the opportunity to learn about E-AI through both learning materials and hands-on experiences with robotics and evolutionary robotics, working on digital and tangible objects.

- Goal 1: Introduce E-AI to children and early adolescents. Based on the profiles of the young learners, activities will be tailored to each of them.
- Goal 2: Create an integrated platform to complement the Teach E-AI 2C learning units. As far as we know, there are no other tools for E-AI that specifically target younger learners and are intuitive and easy-to-use in school context. The project will fill this gap by implementing the Teach E-AI 2C robotic farm, an integrated hardware/software system for evolutionary and interactive robotics. This platform will be implemented in such a way that it can be easily used by children and kids, allowing them to see the fundamentals and concepts of E-AI basics in action and practice them hands-on. In this challenge, implementing a solid and effective system is critical to ensure usability.
- Goal 3: dissemination of educational integrated learning path on E-AI, personalized/customized to different educational needs to a broad audience.

3.3. PTPC-AI

Learning with AI will explore personalized medical education through computer-interpretable clinical guidelines, based on the assumption that the personalization that can be achieved through the use of AI representations and reasoning is key to effective and tailored training for professionals who are not IT, such as physicians. We address the context of continuous medical education, tackling the following goals. Traditional medical education covers a wide range of knowledge. However usually one learns how to act only by practicing on real patients. We want to show that such a scenario can be drastically improved by using AI. We will develop advanced AI frameworks (simulation a nd verification) to train physicians to act on virtual patients, based on the best medical practices described in clinical guidelines. Such frameworks will support the verification and personalization of training processes and will also be available to physicians for their autonomous study and self-evaluation. We will select and acquire guidelines for a specific disease as a case study. However, the educational and AI methodologies developed as part of the project are independent of the specific domain and guidelines.

Our challenge is to lay the foundation for an "AI culture" in healthcare. As a pilot project, it can provide physicians with concrete evidence of the benefits of AI methods. Through a series of lessons, presentations and events, we will promote a culture in which physicians are aware of, trust, and use AI frameworks appropriately. We are members of the "Laboratorio integrato di intelligenza artificiale e informatica in medicina" in which also the Dipartimento di Attività Integrate di Ricerca e Innovazione (DAIRI) of the Azienda Ospedaliera of Alessandria participates. Thanks to this cooperation, we will involve physicians of Alessandria territory. In addition to disseminating key project findings, we will organize presentations and events to show citizens concrete examples of successful applications of AI in healthcare and train a new generation of citizens who are aware of the benefits of AI and want to use them.

- Goal 1: To apply AI methodologies in order to personalize the education of professionals, considering physicians as a concrete example. Specifically, we will address the context of continuous medical education, and we will focus on advanced AI Clinical Decision Support techniques based on computer-interpretable clinical guidelines.
- Goal 2: Design of an innovative AI-based verification framework for evaluation and self-evaluation for the support of personalized training experiences.
- Goal 3. Dissemination is a key challenge in order to lay the foundation for an "AI culture" for professionals, in particular, for what concerns "decision support".

4. Conclusions

The awareness and competence developed through the activities of the three projects aim not only to educate future AI/ICT professionals (e.g., designers, programmers), but also to generate the kind of insight that translates into the mindful and ethical use of tools that are built by exploiting AI techniques.

In perspective, end-users themselves will be able to personalize (their use of) AI systems. An active end-user will not be in awe of the software he/she uses but rather he/she will more likely use it in an effective way, and will be able to interact with professional designers and manufacturers in a productive way. This is necessary to deal with "wicked problems" where the problem statement is incomplete at design time and continues throughout the whole life cycle of a system in order to respond to the ongoing changes of a living world. A fundamental challenge for cultures of participation is to design, create, and develop socio-technical environments that not only enable and support user participation, but also successfully foster it. The goal of supporting domain professionals to develop and modify systems does not imply transferring the responsibility of good system design to the end-user. Normal users will in general not build tools of the quality a professional designer would. However, if a tool does not satisfy the needs or the tastes of the end-users (who know best what these requirements are), then professional designers could assist stakeholders to adapt and evolve their systems. The transition from cultures of consumption (where people are passive recipients of artifacts and systems) to cultures where users are actively involved in developing and evolving solutions to their problems leads to cultures of participation [6], but individual participation is modulated by their individual characteristics. If these are not taken into account, it can prevent their participation in the process and contribute to further concentrating power with a small elite [7].

The medical field is paradigmatic in this respect, and was chosen as a case study also because of its social implications and complexity. The traditional education, provided by medical texts and courses, covers a wide range of knowledge, from human anatomy to the description of diseases and their treatment. But the operative aspect should also deserve special attention: how to operate on a specific patient following the best medical practices? Such an aspect is usually not covered in textbooks and can only be learned by practice on real patients. Clinical guidelines (GLs) encode operational knowledge in the form of general (not patient-specific) evidence-based best medical practices, that support the quality and optimization of health care services. Thousands of GLs have been developed worldwide (see, e.g., https://g-i-n.net/). Studies have shown that the quality of patient treatments is higher when GLs are used and that GLs also have a positive impact in education [8]. However, GLs are usually coded as long texts (even hundreds of pages), making them difficult to consult. Developing training software applications, that exploit the potentialities of using explainable AI for personalizing the education of physicians, is crucial. However, for physicians to make the most of such systems, their understanding of the underlying principles must also be improved.

More generally, the expected impact of the project is to provide testing and training tools to personalize the learning path. First, such tools will allow orienting children and young adults towards AI topics, based on their strongest basic abilities. Second, they will allow the early identification of basic abilities that should be trained to enable a smooth learning experience.

Acknoledgements

This research is funded by Fondazione Compagnia di San Paolo and Fondazione CDP, Bando Intelligenza Artificiale, Ambito Educazione e Formazione.

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