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DEVELOPING AND DELIVERING A HIGH SCHOOL ARTIFICIAL INTELLIGENCE COURSE IN BLENDED AND ONLINE LEARNING ENVIRONMENTS

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Abstract

The paper outlines the development and delivery of Artificial Intelligence to high school students of the American Community Schools of Athens, either as an independent course, or as part of a S.T.E.A.M. course, and the respective instructional design. The topics developed – Impact of Artificial Intelligence, Machine Perception, and Machine Learning – are discussed, including relevant assessments. Additionally, the transition to the online delivery of Artificial Intelligence is presented, followed by reflective views on student learning and suggested future steps.

Introduction

It was only a few years before the beginning of the 21st century that a machine utilizing Artificial Intelligence (AI) – a computer system's ability of effective decision making and problem solving – beat the world champion in the game of chess. Since then, Artificial Intelligence has been increasingly important for the economies and societies of the world, indicatively showcased through the achievements of giant enterprises like Google, Microsoft, IBM, and Amazon. Recently, there have been initiatives to further incorporate Artificial Intelligence into higher and secondary education through projects like Microsoft's AI4All (2020), Google AI (2020), the anticipated creation of the MIT Schwarzman College of Computing (2020), China's Next Generation Artificial Intelligence Development Plan (MOST, 2017) and K12 textbooks (Synced, 2018), and the initiatives of the Association for the Advancement of Artificial Intelligence in the US (AAAI, 2020), among others.

The current paper presents Artificial Intelligence as has been developed and delivered by the author at the high school of American Community Schools (ACS) Athens, as (a) part of a S.T.E.A.M. (Science, Technology, Engineering, Art, and Mathematics) blended-learning course, (b) part of an online S.T.E.A.M course, and (c) a fast-paced semester Artificial Intelligence summer course. Artificial Intelligence at ACS Athens has been

designed as a student-centred, project-based course for technology credits that does not require students to have any prior coding experience.

A sample of learning objectives is the following:

- Demonstrate comprehension of the impact Artificial Intelligence has on societies and economies;
- Demonstrate conceptual understanding of Computer Vision;
- Interact with and conceptually understand the functionality of machines that utilize Artificial Intelligence;
- Conceptually understand the Artificial Neural Networks Machine Learning technique;
- Create Cyber-Physical artworks.

The Artificial Intelligence course has been delivered in context of the 4th Industrial Revolution (Schwab, 2016), and has incorporated elements of the Design Thinking methodology to facilitate project-based learning activities.

This article sheds light into the topics and the assessments of the Artificial Intelligence course (blended and online), includes reflections about the development and teaching of Artificial Intelligence at ACS Athens, and suggests future steps.

A blended-learning High School Artificial Intelligence course

Topics

Figure 1 serves as a conceptual representation of the Artificial Intelligence high school course. The AI course consists of three main topics delivered from the broader (Impact of Artificial Intelligence, bottom of the pyramid) to the narrower in scope (Machine Learning, top of the pyramid), being connected through the Machine Perception topic.

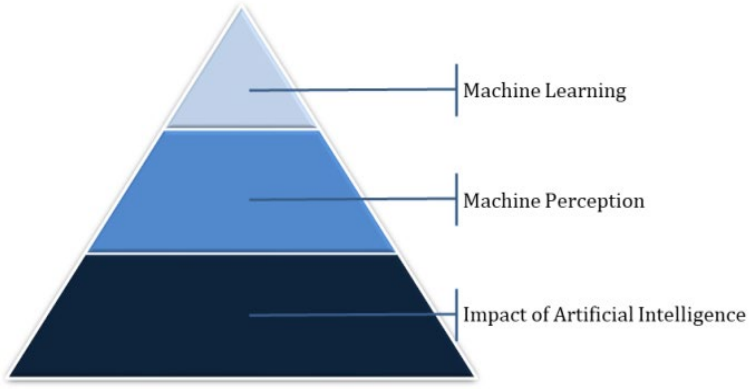

Figure 3. Conceptual representation of the Artificial Intelligence course design

The three topics are outlined below.

Impact of Artificial Intelligence

Aiming in having students become more aware of what Artificial Intelligence is and, most importantly, what is its impact to the world, the course was designed to begin with such an introduction that links the Artificial Intelligence field with societies and economies, as well as with a discussion about the ethical considerations and concerns it brings. AI was presented in context as an important feature, together with 3D printing, Internet of Things etc., of the upcoming 4th Industrial Revolution. Similarly to the effect the previous industrial revolutions had in societies and economies, the first one introducing the use of the steam engine, the second one electricity, and the third one the computers, the 4th Industrial Revolution is expected to be transformative as well, bringing a cyber-physical reality of human intelligence collaborating with machine intelligence (Schwab, 2016). There was special attention to presenting students with examples of using AI for a good cause, not only to reveal its importance, but also to provide students with more balanced information about this field so they could start minimizing possible personal biases on the matter, naturally originating from ignorance.

Machine Perception

After having been introduced to Artificial Intelligence and its (current or anticipated) impact to societies, students deepen into machine perception: how AI machines analyse input from cameras, microphones, keyboards to make decisions, similarly to humans using their senses to interpret the world around them and inform their decision-making. Indicative topics and examples discussed are (a) computer vision & autonomous cars, (b) natural language processing & chatbots, and (c) recommendation systems & Amazon. Beyond discussions, students have the chance to chat with chatbots and interact with intelligent machines (e.g. Experiments with Google, 2020) to sketch, compose music and create poetry in collaboration with AI, connecting with the cyber-physical nature of the 4th industrial revolution. The goal is to not only familiarize themselves with such interactions, but to experience and conceptually understand important concepts of machine learning, like the dependence on representative, un-biased, and sufficient data to perform effectively.

Machine Learning

Removing one more level of abstraction, the instructional design narrows down the focus to the algorithms used to make machines "learn" – the machine learning algorithms. Machine Learning refers to software that is capable of learning from data instead of delivering explicitly programmed output. Since the Artificial Intelligence course is designed as an unplugged one in terms of coding, and given the numerous machine learning algorithms, the students are introduced to selected algorithms (neural networks,

minimum spanning trees, linear and non-linear regression, decision trees, k-means clustering) conceptually (Karampelas, 2018). What is highlighted to the high school students is the fact that even though professionals in academia and business employing machine learning do develop sophisticated software that often times requires a deep mathematical understanding, the basic procedural steps of each algorithm remain more or less the same. Therefore, the relevant concepts can be comprehended by them fairly well, and computational thinking can be showcased efficiently. Also, special care is given to students understanding there are common meta-concepts among many of the machine learning algorithms, like seeking for correlations among data and using thresholds to terminate iterations and make decisions.

Assessments

Being delivered in a blended-learning fashion, Artificial Intelligence activities are designed to encourage students' independent thinking as opposed to a situation where the teacher is the only source of knowledge. Students have the opportunity not only to use or explore online informational resources, but also to interact with online intelligent machines that employ AI. Consequently, the teacher uses a number of different assessments to accommodate for a blended-learning delivery of content and skills. Indicative activities and assessments are listed below:

- Research on AI-related topics (e.g. real-life examples of AI used for good and for bad, ethics, cyber-physical art controversy);
- Read and reflect on online articles (e.g. effect of AI on employment, chatbots and democracy);
- Watch and debrief on videos (e.g. how AI works; computer vision; machine learning; neural networks);
- Interact and create with intelligent machines (e.g. chatbots, Google Experiments);
- Showcase computational thinking (conceptual machine learning).

In the case of Artificial Intelligence running as a high school independent course, as opposed to being part of the S.T.E.A.M. course, students have the opportunity to do personal projects, indicatively:

- Use Machine Learning techniques to investigate correlations among data using spreadsheets or coding (e.g. stock market prices' prediction);
- Research and communicate the mathematical concepts related to a machine learning technique;
- Use online AI software to create cyber-physical art.

Depending on the nature of the project, students' choices and experience, the teacher might need to guide students through coding and statistics. The aforementioned activities have been designed for a project-based course and have not been implemented as part of a summative assessment like tests (neither unit tests nor exams).

Extending the High School Artificial Intelligence course to an online setting

The aforementioned S.T.E.A.M. course was adjusted to also become an online course, offered by The Institute of ACS Athens (2020), with the Artificial Intelligence component been included as well with minor modifications, especially in regards with the Machine Learning topic that require more face to face interaction between the teacher and the students than the other two topics (Impact of Artificial Intelligence, Machine Perception). Most probably, a significant factor for the smooth transition from the blended to the online setting was the fact that Artificial Intelligence was already being delivered in a student-centred fashion with the use of online resources and a variety of assessments. The main focus was to make sure the asynchronous learning design was self-explanatory for the online students and that, independently of the content, would specify the ways students could communicate with the teacher shall they need to. The more students that will be taking the online S.T.E.A.M. course and, subsequently, AI as well, the more meaningful and statistically significant the evaluation of the outlined transition will be.

Reflections

Introducing Artificial Intelligence to students through the impact AI has and will have on societies and economies, including discussing on the on-going debates about for example AI-based Art or the ethical use of AI, has been found by the author to engage the majority of the students, individually or in groups. The absence of mandatory coding activities has also contributed to the same end. On the other hand, the minority of the students that have some coding experience or are willing to begin coding are able to engage with the content at an advanced level, practising Machine Learning in real data. What has been found to engage students the most though was the use of online tools that allow for the interaction between students and intelligent machines running AI, as has been outlined regarding the Machine Perception topic). Regarding Machine Learning, its conceptual delivery has made it possible for students to grow as learners in such a novel and timely topic. Given the fact Machine Learning could often be less intuitive than the rest of the delivered AI topics, hence requiring a strong face to face interaction during class, would possibly need to be designed in a more visual and interactive way in order to be fully transitioned into an online environment.

Finally, the scarcity of Artificial intelligence and, especially, Machine Learning resources for the high school makes the development of such a course a challenging task. The author's own experience as a researcher utilizing Data Mining and Machine Learning (indicatively: Moretti et al., 2018; Karampelas et al., 2012) simplified the process, but it also shed light into the necessity of the training educators need to receive to better adjust to the needs of designing such a course.

Future Steps

Artificial Intelligence offered by secondary education curricula is still in its infancy. Therefore, the field is lacking resources and educators with relevant experience, but the opportunities are many. It is to the hands of policy makers, school administrators and educators to provide students with relevant content and skills that are timely and necessary for the near future. The author lists the following indicative next steps regarding Artificial Intelligence and secondary education, that could be also scaled both ways toward primary education and higher education: (a) development of Artificial Intelligence (blended and online, project-based) instructional designs and curricula, (b) training of educators to teach AI, (c) training of administrators to facilitate the inclusion of AI into school curricula, (d) development of AI interdisciplinary and eventually trans-disciplinary activities (within and beyond S.T.E.M.), (e) development of AI educational resources, including textbooks and interactive software applications, (f) focus on the societal importance of AI and its use for good, including the incorporation of the United Nation's Sustainable Development Goals (United Nations, 2015), (g) focus on AI instructional designs that do not require coding or coding experience, (h) development of machine learning educational activities, both conceptual and ones requiring a more advanced used of mathematics and/or coding, (i) foster partnerships between K12 institutions, higher education institutions, and businesses to share expertise and good practises,(j) encourage research on the inclusion of Artificial Intelligence into K12, and (k) ensure inclusion of underrepresented groups in Artificial Intelligence education.

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