Artificial Intelligence in STEM Education: Interactive Hands-on Environment using Open Source Electronic Platforms

Inteligencia Artificial en Educación STEM: Entorno Práctico Interactivo utilizando Plataformas Electrónicas de código abierto

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Keywords

STEM Education; Artificial Intelligence; open source circuits.

Abstract

This article describes an interactive methodology to teach Artificial Intelligence (AI) through the contructivism philosophy of learning by doing, using, open source electronic platforms, like Arduino, Snap Circuits, Raspberry Pi and Circuit Playground, with an interactive hands-on approach Workshops. These are provided to high school and non-engineering students by (previously trained) engineering students volunteers. The methodology proposed is designed to highlight, in different learning activities, key concepts about Artificial Intelligence (AI). AI abstractes the human intelligence processes through algorithms and computer systems, taking advantage of the amount of data generated nowadays to create innovative, effective, efficient, accurate and at low cost solutions, applied in different fields. The main purpose is to motivate the participants to explode its creativity, improving their innovation skills to provide solutions for XXI century problems, better quality of life, health, among others. A survey will be conducted for the students to find insights about effectiveness of the proposed methodology to better acquire knowledge about AI knowledge. We encourage instructors to use similar interactive hands-on methodologies and to include AI concepts with STEM activities into general education courses. Other concerns of AI, is about the fairness of these algorithms, the inclusion and diversity is a key player in how these systems are built, and it can have consequences as the person perspective when building it The idea of the need for diversity and inclusion of the AI field.

Palabras clave

Educación STEM; Inteligencia Artificial; Circuitos de código abierto.

Resumen

Este artículo describe una metodología interactiva para enseñar Inteligencia Artificial (IA) a través de la filosofía del contructivismo de aprender haciendo, utilizando, plataformas electrónicas de código abierto, como Arduino, Snap Circuits, Raspberry Pi y Circuit Playground, con un enfoque práctico interactivo Talleres. Estos se imparten a estudiantes de secundaria y no ingenieros por voluntarios (previamente formados) estudiantes de ingeniería. La metodología propuesta está diseñada para destacar, en diferentes actividades de aprendizaje, conceptos clave sobre la Inteligencia Artificial (IA). La IA abstrae los procesos de la inteligencia humana a través de algoritmos y sistemas informáticos, aprovechando la cantidad de datos que se generan hoy en día para crear soluciones innovadoras, eficaces, eficientes, precisas y a bajo coste, aplicadas en diferentes campos. El propósito principal es motivar a los participantes a explotar su creatividad, mejorando sus habilidades de innovación para dar soluciones a problemas del siglo XXI, mejor calidad de vida, salud, entre otros. Se realizará una encuesta a los alumnos para conocer la efectividad de la metodología propuesta para adquirir mejor los conocimientos sobre IA. Animamos a los instructores a utilizar metodologías interactivas similares y a incluir conceptos de IA con actividades STEM en los cursos de educación general. Otra de las preocupaciones de la IA, es sobre la equidad de estos algoritmos, la inclusión y la diversidad es un jugador clave en la forma en que estos sistemas se construyen, y puede tener consecuencias como la perspectiva de la persona al construir La idea de la necesidad de la diversidad y la inclusión del campo de la IA.

Introducción

Artificial intelligence (AI) is an interdisciplinary broadly technology in the area of computer science that abstract human cognitive behaviors to create intelligent systems, the emerging of AI has been used, surrounded in applications to solve complex problems and becoming an important disruptive force that provides significant impact in the society [9]; applications can be included in different areas from healthcare, agriculture, automotive, robotics to especially education. In addition, another common field that started to emerge is the robotic field, in which we can find robots in our daily lives, it is important to include them in the education process as well. Besides the inclusion of AI in education, researchers have explored the possibility of teaching AI knowledge into the general learning curriculum to prepare the future for students in STEAM (Science, Technology, Engineering, Arts and Mathematics) fields [1]. But not all the students in Costa Rica have access to robotics.

STEAM Education and AI

AI literacy, recognized as a set of skills, includes technological attitudes, abilities and competencies that people use AI effectively and ethically to solve problems in daily life [10]. To introduce AI knowledge we proposed the use of open source platforms that includes Arduino, Snap Circuits, Raspberry requires creativity and innovative approaches to abstract complex concepts into simple understandable knowledge based on interactive hands-on activities with modular electronic components based on the constructivist philosophy. The authors explored the possibility to teach AI knowledge to high school and non-engineering students exposing the students in STEAM fields, to develop and power the AI literacy set skills, highlighting the awareness of potential ethical issues in the field of AI.

Inclusion and gender diversity

We still find gender imbalance and exclusion in different ways in our society of any form of discrimination, based on gender stereotypes, unfair distribution of power, exclusion based on groups, such as race, class, language, ethnicity, gender, sexual orientation. Leading to a negative environment for minority groups representation, which should be an important concern to address in STEAM education [12]. The authors [12] exposed educational robotics is one resource to promote inclusion, interaction, interdisciplinarity, problem solving, and collaborative work, developing a set skills and cross-functional learning, including: teamwork, cooperative learning, leadership, entrepreneurship, logical thinking, psychomotricity, creativity, curiosity, concentration, and mathematics.

In this article, we present a project initiative to offer a course that consists of a set of workshops on educational artificial intelligence based on the constructivist and constructionism philosophy using open source circuits, like Arduino, Circuit Playground, Raspberry, Snap Circuit, driven by university students engineering volunteers to promote diversity and inclusion in STEAM fields for high school and non-engineering students.

Literature Review

Learning by doing in hands-on activities, based on constructivist and constructionism philosophy usually generalized as the concept related to the result of the learner experience and interaction with the world, allowing the person to learn on his/her own, encouraging the students

to deepen the knowledge avoiding memorization, acquiring meaningful context to understand the concepts. Different previous works have proposed hands-on activities indicated in [2], [3], [4], [5], [6], [7], [8] that achieved student engagement in STEAM fields.

A case of study of a program of ten lessons divided into four modules, proposed by the authors [13], examines the robotics applicability to teaching STEAM subjects in public High Schools, the results of the perception of the students about the course reported that 61.2% tend to STEAM subjects, and 22.7% neutral and 9% low affinity, in addition, the influence of female in STEAM-fields is related to social influence and construct given more importance in early stages.

Authors in [14] explored the educational robotics, a learning tool utilized in science units for 4th grade students for enhancing learning in STEM knowledge and skills, hightled students engaging in the work of building and programming autonomous robots, and concluded the effectiveness of the learning standards required by many states.

Methodology

Educational Artificial Intelligence with Open Source Electronic Platforms

Participants

The course has no cost associated, designed to target high school and non-engineering participants to offer equal, in groups of 20-30 students ranging in age between 15-20 years old to participate in this set of workshops. Students are going to be registered and selected preferably from local and rural public institutions, the objective is to reach as many participants as possible offering equal possibilities for all parties.

Tutors

Tutors teams integrated based on volunteer students from local universities in engineering domains in collaboration with IEEE support [6], the tutors design their own material using the creativity, innovation to be comfortable for them based on the course defined to teach.

Main goals

- Enforce the self-confidence of underrepresented students and disciplines.
- Enrich STEAM concepts in the classes curriculum.
- Incite critical thinking, problem solving, teamwork, leadership, debug abilities, and allow the students to feel comfortable in making mistakes.
- Motivate the idea of the need for diversity, inclusion, and representation of different fields of science in AI research and industry.
- Encourage and incorporate AI in an ethical manner that benefits society.

Program design

Module	Submodule	Content	Fields
Basics in Circuit Playground and Artificial Intelligence	Basics in Circuit Playground	Arduino idle software, Circuit Playground board,	Software and Hardware definitions.
	Introduction to Algorithms and Artificial Intelligence	Initial concepts in programming and artificial intelligence.	Software and Artificial Intelligence definitions.
Building the first led neuron.	Inputs and outputs from the environment	Inputs and Outputs of the Circuit Playground used to capture information from the environment	Software and Hardware
	Getting started with patterns	Initial concepts in pattern recognition	Software
	Introduction of perceptron algorithm	Perceptron, two-class (binary) classification algorithm	Software
Fruit color detection	Light sensor	Photodetector as an input information	Hardware and Software
Piano color fruit	Speaker module	Using the speaker module as an output of the sound wave	Hardware and Software

Basics in Arduino and Artificial Intelligence

The introductory module, students will first be presented with the introductory concepts of logical programming, artificial intelligence basic concepts and Circuit Playground board, such as Circuit Playground board components and idle software. The students will conduct assignments in practice to turn on the leds of the Circuit Playground Board. In the second submodule, students will learn more advanced subjects, such as algorithms, using the Arduino idle software, at this point students will learn basic concepts of artificial intelligence and the bioinspiration of computer and biology related to artificial intelligence.

Building the first led neuron

In this module, the students will be introduced to the subject of pattern recognition to solve problems involving Circuit Playground, utilizing new and more advanced functions to build a basic neuron, the perceptron algorithm, using the sensors included in the board as an input and the leds as outputs, with the goal to identify the pattern and understand how to capture information from the environment and return an output to the environment. At the end of the lesson the students who completed the essential tasks will be assigned in equally assigned groups to solve other pattern recognition tasks involving the circuit playground board.

Fruit color detection

In these modules sessions focus on the second part of the pattern recognition subject. Given a Circuit playground board with different fruits with his own distinct color characteristic, using the light sensors included in the board and the led's, to identify the fruit based on the color, the method of this session is to make teamwork using the divide-conquer approach in a limited time to solve the problem. This is an incentive to build teamwork, communication, manage time and debugging skills.

Piano color fruit

At this point, students will start to work to solve more complex problems, involving the subject of pattern recognition putting everything together of the learned modules, using inputs and outputs from the environment, and the perceptron as a learning algorithm, to identify fruit colors to convert the information into sound waves of piano sheet music. Will be given the circuit playground board and speaker modules. The method for this session is to build and share, given a limited amount of time for one student, the next student needs to continue the work of the previous student until completed or solved the problem. This incite creativity, allow introspective students to feel comfortable, teamwork, communication, sharing and inclusiveness.

Tools

For these sessions the Circuit Playground by Adafruit will be used as a board and the Arduino IDE software to program the code, and load into the board. The Circuit Playground board is a ATmega32u4 micro-processor running at 3.3V and 8MHz, that can be powered from USB or AAA battery. The board comes with 10 mini NeoPixels, 1 motion sensor, 1 temperature sensor, 1 light sensor, 1 sound sensor, 1 mini speaker, 2 push buttons, 1 slide switch, 8 alligator-clip friendly input/output pins, that can act as capacitive touch inputs, red led and reset button [15]. The sensors help to capture information such as motion, light, sound, temperature from the environment. The speaker, leds, and NeoPixels can act as output signals to the environment to provide a feedback loop. The board is programmed using the Arduino IDLE, it uses a wiring language framework of a simplified version of C/C++ programming language. This allows the students to get familiar with the programming language and motivates them to get curious and understand some programming principles.

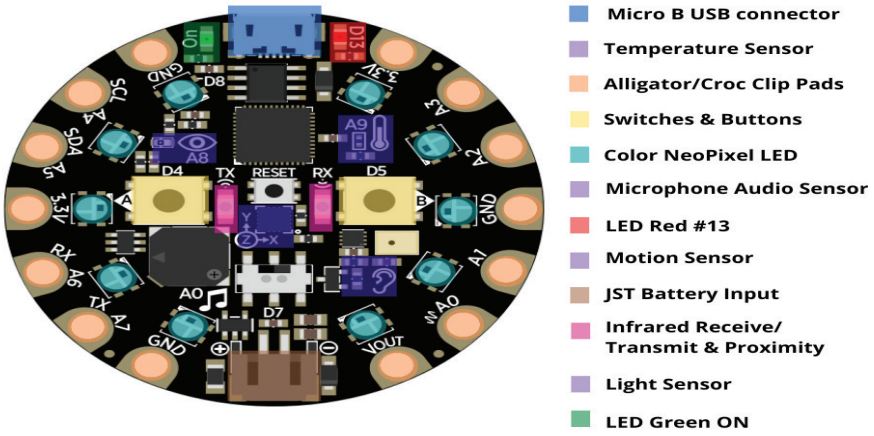

Figure 1. Circuit Playground Express board from Adafruit and the components.
(Image taken from: https://github.com/adafruit/Fritzing-Library)

Course structure

The course is composed of 4 modules design to be a two week plan, started from initial and introductory concepts and getting familiar with the tools, following applying the knowledge in hands-on tasks-projects with progression in complexity

Evaluation of the methodology

To evaluate the achievement of the goals of the project a qualitative and quantitative assessment approach is proposed to conduct the evaluation with the students, to protect the data privacy, this will be carried out anonymously. For the qualitative approach, the students need to log

their experiences in an audio-recorded with explanations and reflections about their learning. In addition, the tutors' will log the observations during the course activities to study student feelings. For the quantitative assessment, questionnaires and interviews were proposed using online forms as Google Forms to evaluate students' prior knowledge, learning experiences and conceptual knowledge acquired from the workshops.

Next steps/ Future work

The next steps involve recluting volunteer engineering students from local universities and preparing pedagogical material, to execute the methodology in local rural high schools and non-engineering students, in a period of 6 weeks, with the financial support of IEEE [6], and evaluate the effectiveness of the methodology through quantitative and qualitative evaluations to measure accomplish of the goals defined.

A future work should aim to extend the methodology to teach AI STEAM education with Arduino, Raspberry Pi, Snap Circuits and other open source boards to identify the advantages and disadvantages to use different boards to introduce AI in STEAM education through open source boards.

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Abstract. This article describes an interactive methodology to teach **Artificial Intelligence** (AI) through the **contructivism philosophy** of learning by doing, using, **open source electronic platforms**, like Arduino, Snap Circuits, Raspberry Pi and Circuit Playground, with an interactive hands-on approach **Workshops**. The methodology proposed is designed to highlight, in different learning activities, key concepts about Artificial Intelligence (AI). The main purpose is to motivate the participants to explode its **creativity**, improving their **innovation** skills to provide **solutions** for XXI century problems, better quality of life, health, environment, entertainment, among others. Other concerns of AI, is about the **fairness** of these algorithms, the **inclusion** and **diversity** is a key player in how these systems are built, and it can have consequences as the person perspective when building it The idea of the need for diversity and inclusion of the **AI field**.

Keywords. STEAM Education, Artificial Intelligence, Open Source, Circuits.

I Introduction

Artificial intelligence (AI) is an interdisciplinary broadly technology in the area of computer science that abstract **human cognitive** behaviors to create **intelligent systems**, the emerging of AI has been used, surrounded in applications to solve complex problems and becoming an important **disruptive force** that provides significant impact in the **society**. Researchers have explored the possibility of teaching **AI knowledge** into the general learning curriculum to prepare the future for students in **STEM fields**. [1]

- STEM Education and AI
- Inclusion and gender diversity

Figure 1. Iterative methodology for AI+STEM Education workshops improvements.

III Future Work

The next steps involve:

- Recluting **volunteer engineering** students from local universities and preparing **pedagogical material** supported by IEEE [2], to execute the methodology in **local rural high schools** and **non-engineering** students,
- Evaluate the effectiveness of the methodology through **quantitative** and **qualitative** evaluations to measure accomplish of the **goals** defined.
- In addition extend the methodology to teach **AI STEM education** with **Arduino**, **Raspberry Pi**, **Snap Circuits** and other open source boards to identify the effectiveness to use different boards to introduce AI in STEM education through **open source boards**.

Figure 2. AI+STEM Education.

II Methodology

Participants. High school and non-engineering participants to **offer equal**, in age between 15-20 years old offering **equal possibilities** for all parties. ***Tutors.*** Design their own material, integrated based on **volunteer students** from local universities in engineering domains. ***Tools.*** **Circuit Playground** by Adafruit will be used as a board and the **Arduino IDE** software to program the code, and load into the board.

Main goals.

- Enforce the **self-confidence** of **underrepresented students** and disciplines.
- Incite **critical thinking**, **problem solving**, **teamwork**, **leadership**, **debugging** skills and allow the students to **feel comfortable** in making mistakes.
- Motivate the idea of the need for **diversity**, **inclusion**, and representation of different fields of science in **AI research** and **industry**.
- Encourage and incorporate AI in an **ethical** manner that benefits society.

Evaluation of the methodology.

Qualitative and **quantitative** assessment approach is proposed to conduct the evaluation with the students.

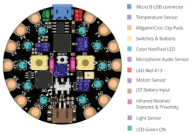

Figure 3. Components of the Circuit Playground Express Board by AdaFruit. (Image taken from: https://github.com/adafruit/Fritzing-Library)

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Table 1. Program design. Workshops for AI+STEM Education

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