European Journal of Engineering and Technology Research
Vol 1 | Issue CIE | December 2023
ISSN 2736-576X

RESEARCH ARTICLE

The Applied Model Approach in a Skills-Based Education

Spyridon Adam*, Ioannis Katsiris, Loukas Michalis, and Spiros Panetsos

ABSTRACT

As science advances at a great pace, transforming businesses and the industry, companies reassess the skills and competencies that are demanded from new candidates, shifting from the old model that valued specialized knowledge to one that prioritizes skills, like critical thinking, creativity, communication, collaboration. Higher Education follows suit, as many Universities across the world redesign their programs towards a skills oriented education. In this paper, we discuss the applied model approach as an effective scheme to achieve a skills based education. We provide an illustrating example of the implementation of this model in the Data Acquisition Lab, in the 8th semester of the Electrical and Electronic Engineering Educators program at the School of Pedagogical and Technological Education (ASPETE).

Keywords: Applied Model, Internet of Things (IoT), Robotics, Skills Based Education.

Submitted: December 04, 2023

Published: December 29, 2023

10.24018/ejeng.2023.1.CIE.3140

Department of Electrical and Electronic Engineering Educators, School of Pedagogical and Technological Education (ASPETE), Greece.

Corresponding Author:
e-mail: spadam@aspete.gr

1. Introduction

When Alexander was 13 years old, King Philip asked Aristotle to take up the training of young Alexander and his friends of the Macedonian nobility. A few months later, King Philip asked Aristotle:

"How is Alexander doing?"

Aristotle offered a swift reply:

"Well".

King Philip kept asking Aristotle about Alexander's and his friends' progress. But every time, Aristotle met him with the same response:

"Well".

Then, one time, King Philip, apparently not satisfied with that response, asked him:

"What do you mean well? Haven't you been teaching them astronomy, geometry, science, philosophy? What have you been teaching them, all this time?"

To that, Aristotle replied:

"I have been teaching them how to think".

Aristotle, in his response to King Philip, possibly, captured the most vital aspect of education. Education, though, aims to do more than teach us how to use our brains.

While refining our thought process and sharpening our intelligence, education aims to build "character", as well. Education is about building discipline, determination, will, and mental endurance in pursuit of achieving our true potential.

Another aspect of education concerns our emotional intelligence. Cognitive and emotional intelligence are intimately and intricately related. Bertrand Russell, in his treatise *on Education* [1], stressed the balance with which education should affect the cognitive and emotional self by proposing that education should act to enhance four fundamental qualities: "intelligence, vitality, courage and sensitivity" [1].

The third aspect of education is the most obvious. Education has to develop skills and qualities of character. At its most basic, it has to convey knowledge. We can even go a step further and claim that, as much as possible, education has to deliver fresh ideas and current knowledge.

1.1. A Wealth of New Ideas

For all its problems and misgivings and to a degree, in response to the pressing need to address and solve these problems, our time is characterized by an exorbitant progress in science at a pace, perhaps, not seen before. There is a wealth of astounding ideas and possibilities.

The quantum computer, nuclear fusion, sucking carbon out of sea and air are some of the most groundbreaking. In an experiment at the Lawrence Livermore National Laboratory in California, they managed to create a record amount of energy by "fusing hydrogen atoms into helium, mirroring the reactions that occur inside the sun" [2]. Because fusion involves joining rather than splitting atoms, there is almost no radioactive waste and the result raises hope that one day, nuclear fusion could provide a near-limitless source of clean energy [2].

Private investors did not await the results from the experiments at the Lawrence Livermore National Laboratory to venture into this area. However, risky and distant nuclear fusion is considered to be, private investors have set up companies to produce power through fusion [3].

Green energy, on the precedent of the large offshore wind farms, has started to be seen not merely as something good for the environment, but as a profitable investment, as well. Thus, large private funds have started to be invested in companies and technologies that target the hard task of pulling out CO_2 from the air and the oceans [3].

Closer to our own discipline in Electrical and Electronics Engineering, we find equally groundbreaking ideas and challenging tasks. We single out the advances in robotics, the idea of distributed systems, the Internet of Things (IoT).

The first has led to the digitization of the Industry [4]. Indicating the present and future in robotics, in an event about this time, last year, Elon Musk presented Optimus[1], the humanoid robot that Tesla has been developing [5]. The robot is aimed to staff the assembly lines, at least, in the Tesla factories where, exclusively, it will take up every task in the assembly of Tesla's electric car models.

The second, namely, distributed systems is the architecture of Blockchain [6] that, we believe, will entirely transform the banking and investment industry. Perhaps, more importantly, our brain has the architecture of a distributed system which means that any system aiming to emulate functions and tasks of our brain has to be built on this architecture.

If robotics means embedding some of our own intelligence into systems, the Internet of Things (IoT) brings another great potential: connectivity and connected systems. The ability to talk and control systems wirelessly (human2machine), the property of systems to communicate with one another (machine2machine).

Systems, increasingly, combine built-in intelligence and communication. Stressing one or the other leads to distinct system designs: edge vs. cloud computing. In edge computing, the data is processed locally, right in the device where it is collected [7], [8]. Cloud computing, in contrast, involves sending the data from local devices to the cloud, for processing [8]. There, various algorithms process the data and control the devices at the edge, that is, where the data is collected or where motors are operated to perform various tasks.

1.2. *A Very Innovational Landscape*

Above, we attempted a quick view of the market. To capture some of its vision, view some of the most ingenious ideas and challenging projects that companies and entrepreneurs undertake. What do we make of this market?

In our view, it is an environment bursting with energy, creativity, and imagination. Where people have bold ideas, are not afraid to take risks, chase their dreams, and shape the world to their vision.

Shouldn't education have some of the market's boldness, energy, creativity, and resourcefulness? If we recall Bertrand Russell's ideal of education, we will notice that those are precisely the qualities of the education he envisions. He names them by similar terms: "courage, vitality, creativity, intelligence" [1].

2. Education 4.0: A Skills-Based Education

The world is changing at a great pace. We've seen above that Science advances boldly and with great strides, taking up and devising solutions to the hardest problems, transforming key industries—energy, telecommunications, and banking at a rate and degree that by many is considered to amount to the 4^{th} Industrial Revolution [9].

As technologies and industries change at a pace that the most up-to-date technology will be rendered outdated in a few years [10], companies reevaluate the skills and competencies that are required in new candidates, shifting from the old model that valued specialized knowledge to a new model more in line with Russell's ideal of education, prioritizing critical thinking, creativity, communication, collaboration, skill and drive to learn new things.

In this context, education, following suit with companies and the industry, finds itself forced to reconsider what it seeks to achieve. Already, Higher Education Institutions redesign their Programs of Study on a new model, adopting schemes like a research based education (University College London) [11] or skills-based education (National Technical University) [12] and attempt approaches like the applied model approach (ASPETE), as discussed herein the sequel to implement those schemes.

3. The Applied Model Approach

The applied model approach is based on the idea that the students will better learn the theory if they use it to build a system. That system should be inspired by a real world system or one that solves a real world problem. The intention for this model—system that we will build in class is to be complex enough and capture enough features of the actual system, as to have some real world relevance. Yet, not too complex to be able to use it to illustrate fundamental theoretical concepts.

Before we expand on the applied model approach, allow us a word about our School that will clarify the scope of this approach.

The School of Pedagogical and Technological Education (ASPETE)[2] was founded by Niki Antonakaki with the vision of building an elite School of Technical and Vocational Training. For long, the School's sole purpose was to train the Educators that would teach students in the Technical and Vocational Schools of Secondary Education, in Greece. Now, our graduates, mostly, work as engineers in engineering firms and the industry. However, the School maintains its original identity to train engineers-educators.

[1] https://www.wsj.com/articles/tesla-ai-day-2022-elon-musk-11664536415.

[2] https://www.aspete.gr/.

The studies lead to a degree with a double major in Education and the Science of Engineering.

Fig. 1. A simple example of the applied model is BRAT, a 6 degrees of freedom humanoid we have been using in the Lab for students to study bipedal motion.

The applied model approach is in line with and derives from the School's objective to bring together two seemingly unrelated disciplines: Education and Engineering. In this sense, it attempts to reconcile the pedagogical with the real world that, often, involves a complexity beyond that suitable for illustrating theoretical concepts.

An example of the applied model is BRAT, a 6 degrees of freedom humanoid robot (Fig. 1) that has been used in our Lab, primarily, for undergraduate students' theses. BRAT is a very simple humanoid that doesn't do much, apart from walking around. Even so, BRAT illustrates the complexity of bipedal motion, for example, the need to balance on one foot as we make a step, enabling students to experiment with programming a robot to walk which is a necessary stage before attempting the more practical, but much harder task of building robots that can do more useful and productive tasks than BRAT, like, handling objects.

As BRAT, possibly, illustrates, the applied model has three defining features:

1. It is inspired by a real world system;
2. It is challenging enough to enable learning key concepts and developing skills, but not too complex to overwhelm students;
3. It can be scaled to a more complex, closer to the real world system.

4. The Data Acquisition Lab: An Illustrating Example

As an illustrating example of the applied model approach, we present an overview of the way we taught the Data Acquisition Lab[3] during the Spring 2023 semester. The Lab is taught in the 8th semester of the Electrical and Electronics Engineering Educators Program at ASPETE.

The Lab was organized around two projects: the 2-wheel robot and communication over Bluetooth. The topics were picked to introduce the students to two key ideas and major applications in Electrical and Electronics Engineering. On the one hand, robotics and control systems, and on the other one, the wireless communication between devices as in the IoT. The project-based structure of the Lab was meant so that by the end of the Lab, the students should have built a system and completed a project, rather than a bunch of unconnected weekly lab experiments.

We built the two systems bottom-up, dividing them between the weekly meetings during the semester. Each week, we studied and built a different part of each system. Throughout the term, we interchanged between the two projects, as is shown in Fig. 2, so that all students got exposed to the core concepts in each system.

Near the end of the term, though, the students had to work in teams. Each team had to choose one of the two systems and on their own, expand on it. Either implement the full Proportional Integral Derivative (PID) Control [13], [14], if they choose to work on the 2-wheel robot or get data from sensors on their mobile over the Bluetooth, if they choose that project. Finally, each team had to present their work.

In the next section, is a more detailed description of the procedure we followed with each system in the Lab.

4.1. *The 2-Wheel Robot*

The 2-wheel robot is about balancing. Therefore, the 2-wheel robot is about control systems to help the robot keep its balance while moving around space (Fig. 3).

The robot illustrates the modern design of control out of a microcontroller, sensors, motors, and a program that runs the control system, whether PID or other, on the microcontroller. But the 2-wheel robot also illustrates the fundamentals of embedded and robotic systems. How we integrate a microcontroller into an analog circuit [15], process the signals from sensors, control through motors, and the system's action in the environment.

We have used a robotic kit to assemble the 2-wheel robot, the 2-Wheeler Balancing Robot[4] by Osepp (Fig. 3). The students were split into groups. Each group worked on its own robot, assembling the robot, then mounting the hardware onto the platform and, finally, programming and testing the robot.

The 2-wheel robot gets its sense of balance from the MPU6050 accelerometer—gyro. The gyro is mounted on the robot's frame and measures the robot's angle from the vertical axis. The robot's motor control system which gives the robot its motion consists of two DC motors operating at 12 V and the motor driver, the L293D.

[3] https://eclass.aspete.gr/courses/EHL118/.
[4] https://www.osepp.com/robotic-kits/6-2wheeler.

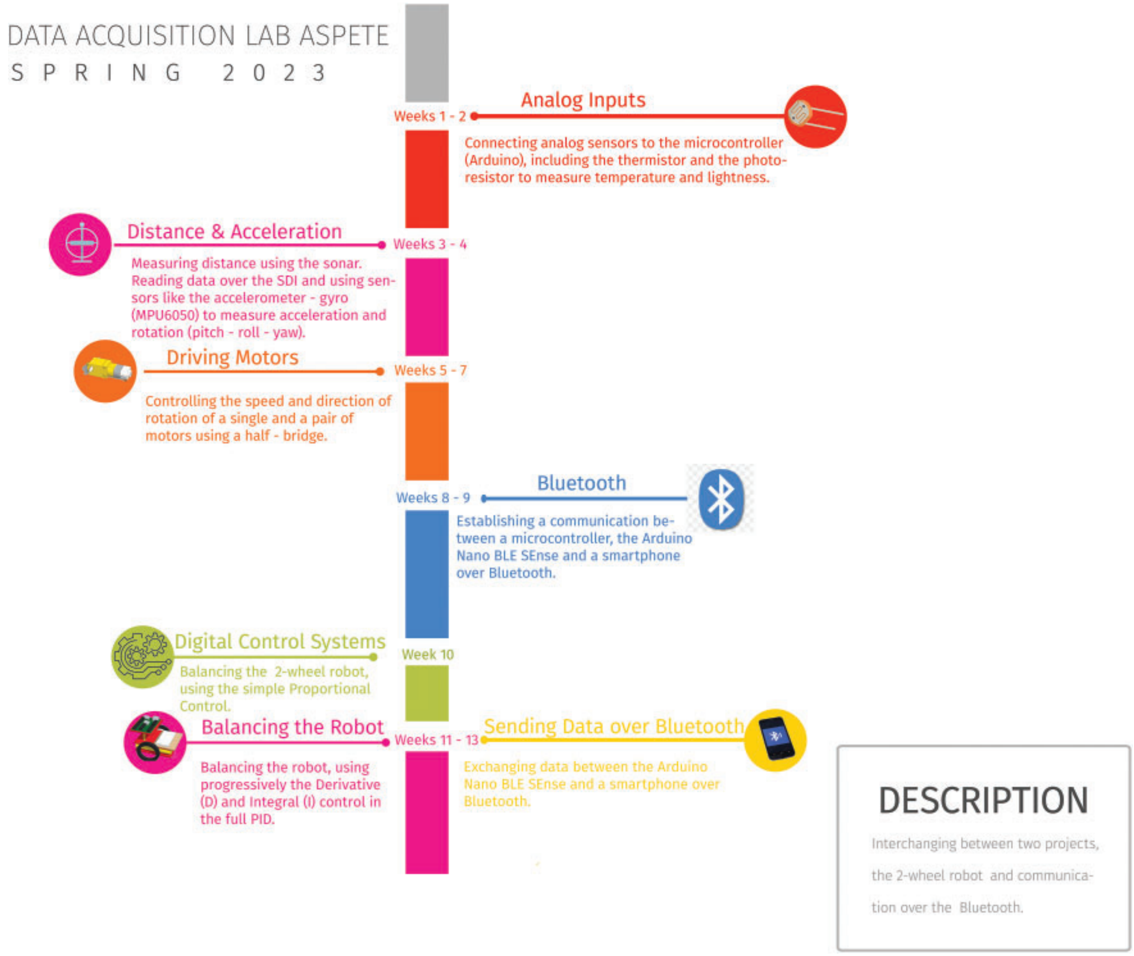

Fig. 2. The Lab was organized around two projects. We carried them out through the Term, interchanging between them in the weekly meetings. Near the end of Term, the students had to choose to further develop one of them, working in teams.

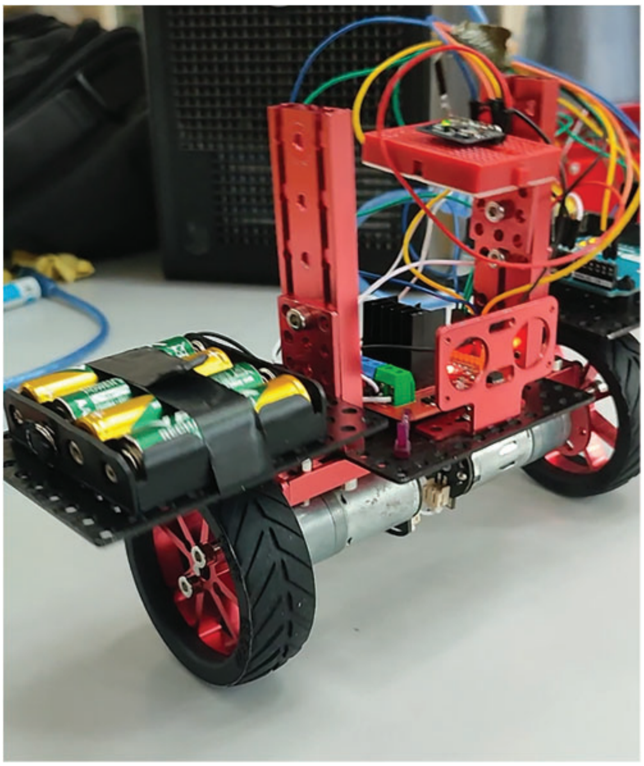

Fig. 3. The 2-wheel robot we built in the Lab based on Osepp's kit.

The system's Central Unit is an Arduino Uno. This is where the signals from the MPU6050 are processed to determine the system's state of balance. It is also the control unit that checks the robot's balance based on the signals from the MPU6050 and controls its motion, moving the robot forward at constant speed if it is balanced, accelerating forward if it tends to fall in front or accelerating in the reverse direction, it is falling back (Fig. 4).

The students could also work at home, using an online platform for simulating the robot. Robot Operating System (ROS)[5], perhaps, is the most advanced, used for building and simulating robotic systems for real world applications. We used Tinkercad[6], an online circuits' design and simulation platform designed by Autodesk as our simulation and prototyping platform and a platform for the students to work on and submit assignments, like a simple model of the 2-wheel robot (Fig. 5).

Modelling the 2-wheel robot in Tinkercad helped the students see the main ideas in the circuit and the program by building a simpler version of the system, part by part on their own. The 2-wheel robot is not such a complex system to require prototyping in a virtual environment. The motivation for using Tinkercad, primarily, was that each student, on his own, build a model of the system and

[5] https://www.ros.org/.
[6] https://www.tinkercad.com/.

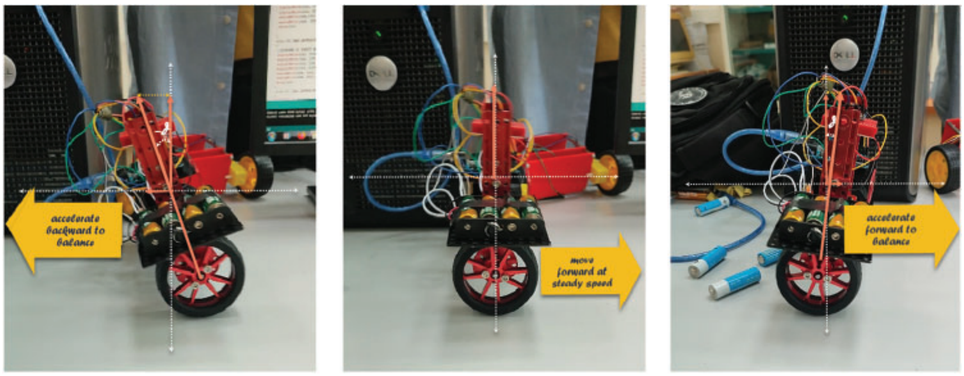

Fig. 4. The algorithm for balancing the 2-wheel robot works as a state-machine switching between three states. When the robot tends to fall back, we accelerate backward to restore its balance (left). When it is balanced, we move the robot forward at a constant speed (center) while if it tends to fall in front, we accelerate forward (right). You can see the robot's actual performance in the following students' videoc from the lab: https://youtube.com/shorts/6yWp8Zl5ADo and https://youtu.be/ag-s6jYLUDw.

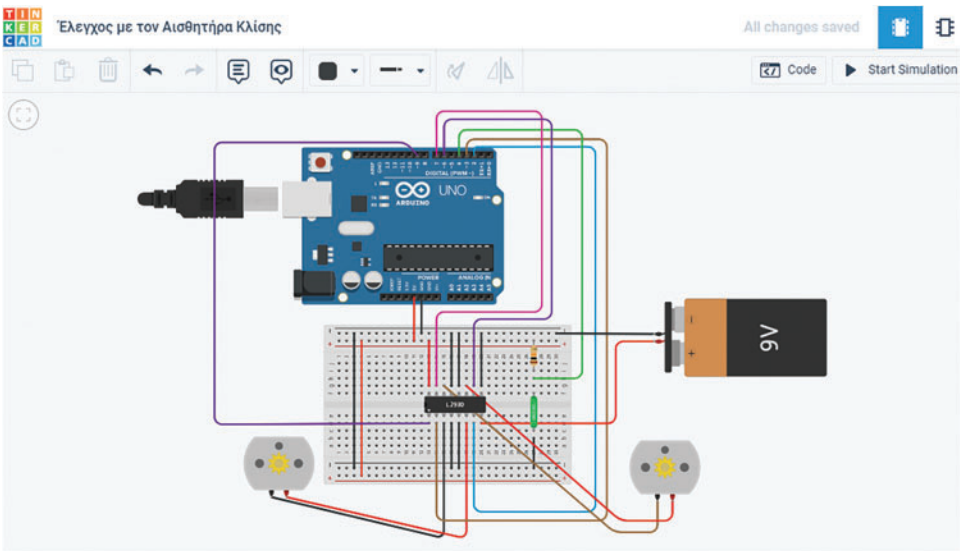

Fig. 5. The virtual model of the 2–wheel robot in Tinkercad.

develop his/her own understanding of the system before going to work in a group to build the actual system.

4.2. Connecting a Device to A Smart Phone Over Bluetooth

The second project was on Bluetooth, programming a microcontroller, the Arduino Nano Ble Sense [16] to connect to and communicate with a smart phone over Bluetooth (Fig. 6). The Bluetooth project involved a different aspect of embedded systems. If the 2-wheel robot was about an MPU interacting and controlling analog components, this project is about wireless connectivity—the hardware and the program that we need to write to connect a device to the web or another device, like a smartphone, and establish communication between the two.

Through the project, we attempt to look at what connecting a system over Bluetooth involves. What hardware do we have to use and what code do we need to write to establish that connectivity on both sides: the code on the side of the device, as well as the App we have to develop or use on the side of the smart phone. Another objective of this system is to start looking at the Internet of Things.

This is because Bluetooth, in addition to the perception as one-to-one communication technology, also, enables us to build a Wireless Personal Area Network (WPAN) [16]. In that network, we can connect several devices that can communicate with one another within a short range (Fig. 7).

The other connection of this project to the IoT is the particular Bluetooth protocol we use which is the Bluetooth Low Energy or BLE instead of the Classical Bluetooth [17]. Bluetooth which owes its name to the Danish King Harald Bluetooth (911–986 AC) was originally developed by Ericsson to exchange data between devices [17]. The Bluetooth Low Energy or BLE came up in 2011 and constituted a break from the scope and function of the original Bluetooth.

Bluetooth Low Energy (BLE) operates in the same 2.4 GHz band as classical Bluetooth. But, as its name suggests, has a much lower consumption of energy and a much higher transmission rate (1 Mb per second). That makes it suitable for the IoT. While classical Bluetooth is meant for the exchange of data, like live talk, videos, and files between devices that can take up to several hours, BLE is intended for the short exchange of data that lasts up to a few millis each time [17].

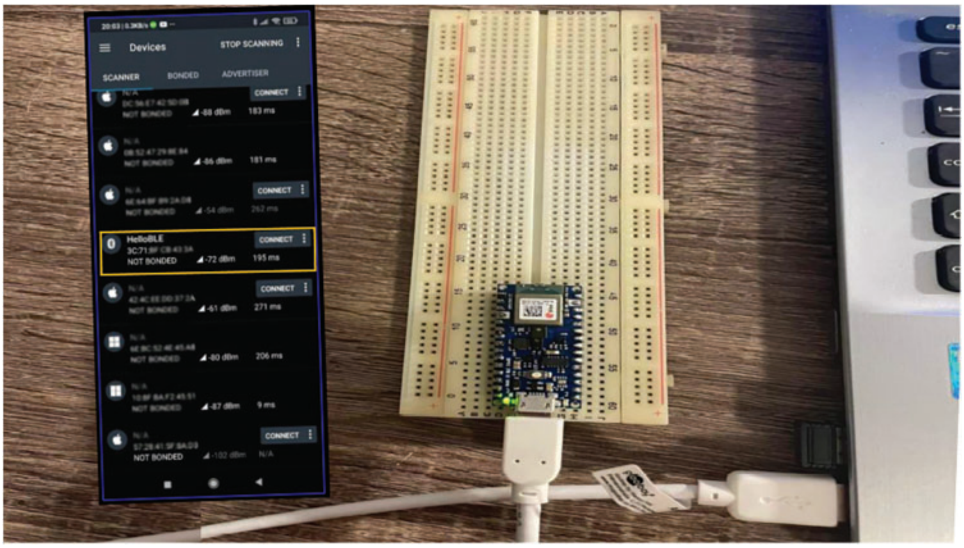

Fig. 6. The communication of the Arduino Nano 33 BLE Sense (right) with a smartphone (left) over BLE. On the smartphone, we run the nRF Connect App to detect and exchange data with the Arduino.

Fig. 7. The Bluetooth creates a network over which not just 2, but several devices can get connected and communicate with one another. A network established over Bluetooth is called Wireless Personal Area Network (WPAN).

The procedure we followed in this project to establish communication between two devices—a microcontroller (Arduino Nano BLE Sense) and a smartphone —and start exchanging data between the two over Bluetooth is detailed in the Appendix.

5. Discussion

The two projects that we have discussed in this paper, are meant to illustrate the applied model approach we take to teaching the Data Acquisition Lab with the aim to:

1. Present some of the most fascinating new ideas in Science and Engineering.
2. Stimulate the students' interest in those ideas.
3. Teach them the principles in the design of modern systems.
4. Present core Engineering concepts, like control systems in a hands-on approach.
5. Develop skills, primarily, targeting creativity, thinking, problem-solving by emphasizing the logic of a solution, using the code as means not so much to learn a programming language, but to learn to use and apply computational thinking to a problem.

Does this approach work? Has it helped the students better grasp the core concepts of the Lab? Has it helped them perform better and achieve higher marks? Become more creative? Develop skills? What skills?

5.1. Integrating Concepts from Different Areas of Engineering

These projects are about connecting systems and devices, but also work to connect seemingly disparate concepts, like circuits, control systems, and programming, and bring them together in the design of systems.

For almost all the students, before taking the class, there was no connection between analog and digital electronics and programming. Working to develop the systems discussed in this paper, they learned to combine and not to detach. More than ever before, Engineering emerged not as disparate fields, but as a Science unifying and bringing together concepts from all these areas into the design of systems.

5.2. Hands on Approach

The students learn the most widely used algorithm of control systems, the PID control by building this control into an actual system, the 2-wheel robot.

They learn programming by writing programs in C++, testing, and debugging these programs in actual systems. Ranging from simple systems that read sensor data and control motors to more complex near real world applications that implement PID control and connect systems over Bluetooth.

Fig. 8. An indoor positioning system based on Bluetooth beacons.

5.3. Developing Problem-Solving Skills

Through the projects, the students develop their analytical thinking and problem-solving skills.

5.4. Seeing the Forest and the Trees

Organizing the weekly Lab meetings around two-term projects, we manage a more coherent and integral, single-story structure to the Lab. By dividing the development of these projects into weekly Lab meetings, we can go deep into the details of a different part of each system in every class.

Those weekly meetings are not about disparate experiments. They look into different concepts and ideas through parts of a single system and, progressively, combine these parts into the whole system.

5.5. Learning by Presenting

The students were graded in the Lab based both on individual and group work. Individual work involved assignments on building and simulating models of the systems in the projects in Tinkercad. Group work involved further developing one of the actual systems in the Lab. The grading was based on midterms and a presentation in small groups of 2–3 students on one of the two projects, at the end of the term.

The final exam tested the finer grained details of the concepts in the Lab. The degree to which the students managed to grasp these concepts and develop the skills we sought.

The presentations worked in a different manner. They enabled the students to talk about the ideas and concepts in one of the projects in their own words and from a different perspective. Not from a learner's but from an expert's perspective. At least, from the perspective of someone who has worked on a project and attempts to convey to others, what that work involves and the potential applications.

The presentations also offered a larger scale view of the projects that shifted away from the details of the implementation and, instead, attempted to capture the main ideas and the potential applications.

5.6. Scaling to Real World Applications

Earlier in the paper, we mentioned that one of the main features of the applied model is that it can be scaled to a system for a real world application.

Let's, briefly, see this feature with respect to Bluetooth. We built a system that connects an MCU, the Arduino to a mobile phone. We can embed the Arduino into a circuit containing various sensors and motors. Through the connection to the mobile phone, we can read the data from the sensors and/or control the motors from our mobile over Bluetooth.

A real world application of this system is indoor positioning (Fig. 8). Indoor positioning involves estimating a person's position inside a building complex. GPS appears to be the obvious solution but does not always work indoors. Thus, the idea is to use Bluetooth instead of GPS for indoor positioning and navigation.

Indoor positioning and navigation have several applications. Inside building complexes, like malls, airports, libraries, museums, hospitals, and college campuses, an App that detects a visitor's position and displays a map of the surrounding area based on his position can help him, easily, find his way around. At the Athens International Airport, they are keen to develop an App that will locate a visitor's position at the airport and guide him from his current position to his gate or any other place at the airport.

Such an App is also very useful to stores for a different purpose. A recent practice and a new potential in stores is to locate each client's position in the store. Actually, to follow each client through the store; not so much to help him find his way around rather than orient him to the merchandise and based on his location in the store to send to his phone promotional messages for the products in that section of the store (Fig. 8).

Since this idea can help boost sales, developers have started to develop Apps that follow/track clients through their shopping at a store. These Apps use a client's phone and Bluetooth to locate his position at the store at any time.

Bluetooth devices like the Arduino of our second project are placed at various locations in the store (Fig. 8). These devices are the beacons that continually emitting signals over Bluetooth, aiming to detect clients' phones at nearby locations. Provided that the client has installed an App on his phone like the App in our project that can detect and communicate with the Bluetooth beacons in the store, then it will pick up the signals from the beacons and reply to them.

Once communication between a beacon and a client's phone is established, then the beacon can use the signal from the client's phone to estimate his distance. Based on that distance, the beacon or a more central system that uses the information from the beacons can send to the client's phone promotional messages for the nearest products.

6. Appendix

Below, in some greater detail, we describe the procedure for establishing communication between the Arduino Nano BLE sense and a smartphone over Bluetooth.

Bluetooth communication follows the client–server model of communication between devices over the web [16]. Though, using a slightly different terminology. Each BLE device can act as a bulletin board or a reader [16]. When it serves as a bulletin board, we can expose some data to all BLE devices, which are BLE readers. The BLE specification also provides a notification mechanism to alert readers when data are changed.

There are several ways to embed Bluetooth functionality into a system. We chose the Arduino Nano 33 Ble Sense Board (Fig. 6), having the nRF52840 microcontroller which is an ARM CPU from Nordic Semiconductors. The board has a built Bluetooth Low Energy (BLE) module and several internal sensors, which is why the name Sense.

In the project, the Arduino serves as the bulletin board on which we publish the data coming from the sensors on the board or other sensors that we connect to the board. On the other side, a mobile phone acts as the reader (Fig. 6).

6.1. *Coding a Device to Act as a Bulletin Board*

The code for a BLE device to act as a Bulletin Board involves some fixed steps which are performed by simply calling corresponding functions from the BLE Library [16]. Those steps are shown in Fig. 9. The logic of each of these steps is as follows:

1. Activate the BLE radio on the Arduino Nano 33 BLE Sense by calling the **BLE.begin ()** function.
2. Advertise our BLE with a specific BLE name. This is the name by which the Arduino will be detected by the reader devices. We define this name which is of our choice by calling the **BLE.setLocalName ()** function.

In addition, we have to set a BLE UUID. The Universally Unique Identifier (UUID) is a 128-bit integer number used to identify resources. We can generate a UUID for our device by using the online generator at https: https://www.uuidgenerator.net/.

3. Then, we set the UUID that we generated as the unique id of our device by calling the **BLE.setAdvertisedServiceUuid ()** function.
4. After setting the name and UUID of our device, we wait for incoming BLE readers by calling the **BLE.central ()** function on a loop. Once a BLE reader is connected to our BLE radio on the Arduino Nano 33 BLE Sense, we can obtain its id through the BLEDevice object.

The code in Fig. 9 sets up the connection on the side of the Arduino. Connecting a smartphone or simultaneously, several smartphones to Arduino over Bluetooth requires coding too. That code has the form of an App that works to detect and start exchanging data with the Arduino.

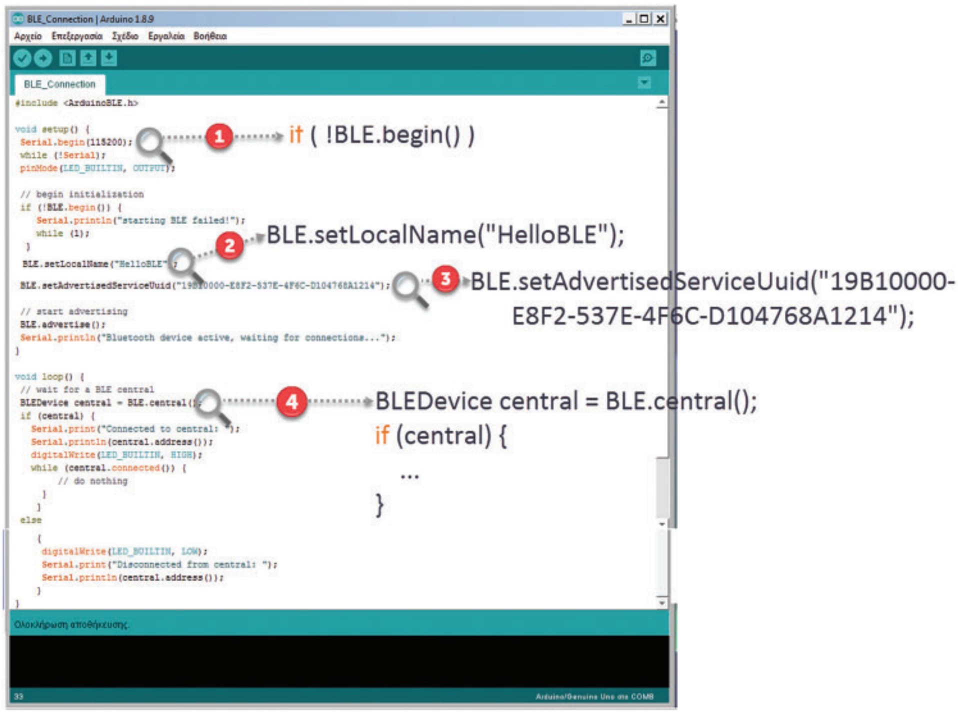

Fig. 9. The code that enables the Arduino to be connected to other devices over Bluetooth. The code relies on 4 functions from the BLE library Activate—Advertise—Set the UUID—Check whether other devices are connected.

Depending on the Bluetooth chip we are using, usually, we can usually download this App. Since we are using the BLE protocol and an nRF chip on the Arduino, we can connect a smartphone to Arduino over Bluetooth by installing the nRF Connect App. We download this App for both Android and Apple phones.

Once we upload the code in Fig. 9 onto Arduino and install and run the nRF Connect App on a smartphone then we establish the connection between the two and we can start receiving data from the Arduino on the smart phone or even control the Arduino from the smartphone over BLE.

Funding

The authors wish to acknowledge the financial support to this work by the Special Account of Research Funding (ELKE) of the School of Pedagogical and Technological Education (ASPETE), in Athens, Greece.

Conflict of Interest

Authors declare that they do not have any conflict of interest.

References

[1] Russel B. *On Education*. Abingdon, Oxon: Routlege; 2010.
[2] Blakely R. *Advance in Nuclear Fusion Raises Hope of Clean Energy*. The Times; August 7, 2023.
[3] Fortson D. *The Tech Tycoons Sucking Carbon Out of Sea and Air*. The Sunday Times; July 30, 2023.
[4] Markillie P. *Making the Future. Special Report: Manufacturing and Innovation*. The Economist; April 21, 2012.
[5] Bobrowsky M, Elliot R. Elon musk unveils prototype of tesla's humanoid robot optimus, says it will cost less than a car. *Wall Street J*. 2022 October 1. Available from: https://www.wsj.com/articles/tesla-ai-day-2022-elon-musk-11664536415
[6] Infante R. *Building Ethereum Dapps: Decentralized Applications on the Ethereum Blockchain*. Shelter Island, NY: Manning Publications; 2019, pp. 11964.
[7] Perry L. *Edge Computing*. Shelter Island, NY: Manning Publications; 2023, pp. 11964.
[8] Yeaung T. *What's the Difference between Edge Computing and Cloud Computing?* Nvidia; 2022. [Internet]. Available from: https://blogs.nvidia.com/blog/2022/01/05/difference-between-cloud-and-edge-computing/.
[9] Markillie P. *A Third Industrial Revolution. Special Report: Manufacturing and Innovation*. The Economist; April 21, 2012.
[10] Suich Bass A. *GrAIt Expectations Non-Tech Businesses are Begin-Ning to Use Artificial Intelligence at Scale*. The Economist; March 31, 2018.
[11] University College London. Research-based education [Internet]. 2023. Available from: https://www.ucl.ac.uk/prospective-students/undergraduate/why-choose-ucl/research-based-education.
[12] National Technical University of Athens, School of Mining and Metallurgical Engineering (SMMM). The new undergraduate curriculum of the SMMM. [Internet]. 2023. Available from: https://www.metal.ntua.gr/?page_id=14525.
[13] Nise N. *Control Systems Engineering*. 8th ed. John Wiley and Sons; 2019.
[14] Unsalan C, Barkana D, Gurhan D. *Embedded Digital Control with Microcontrollers*. 1st ed. Wiley; 2021.
[15] Essick J. *Advanced LabVIEW Labs*. 1st ed. Upper Saddle River, New Jersey: Prentice Hall, Pearson Education; 1999.
[16] Kurniawan A. *IoT Projects with Arduino Nano 33 BLE Sense*. 1st ed. Apress.
[17] Link Labs. Bluetooth vs bluetooth low energy. What's the difference? [Internet]. 2023. Available from: https://www.link-labs.com/blog/bluetooth-vs-bluetooth-low-energy.