Promoting Stem Education With Arduino Activities In A Blended Learning Course

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ABSTRACT

The purpose of this paper is to promote the understanding of students on STEM (Science, Technology, Engineering, and Mathematics) concepts. To work towards this fundamental aim in a time efficient method, we developed a blended learning course consisting of online material and practical on site activities. More specifically, a structured course consisting of units with specific objectives, video lectures, try-out activities and online tests has been developed. A number of schools have been invited to enroll to this course and Arduino kits have been delivered to them in order for the students to implement the practical activities. Each student group had to complete the course within a short period with the supervision of their teacher. Students have enthusiastically completed all the activities with the aid of their teachers. After the course, they could better understand issues like the utility and importance of switches, resistors, capacitators and in general of the principles of electronic circuits.

INTRODUCTION

Students can undoubtedly operate computers and mobile devices quite effectively, but most of them have little understanding of the inner workings of a computer and in general of the working principles of electronic devices. Therefore, the need to promote the understanding on these topics, which fall under the broad term of STEM (Science, Technology, Engineering, and Mathematics) education (Breiner et al., 2012), is essential. Moreover, in a rapidly changing era, students have to develop skills and practices involving innovative technologies, in order to be competitive and successful. To work towards this fundamental aim in a time efficient method, we developed a blended learning course consisting of online material and practical on site activities.

Empirical research has shown that learning can be improved when instructors follow a more student-centered, interactive instruction (Handelsman et al., 2004). STEM education projects are student-centered as the learners have to build and test various tools and systems and comprehend through this process various theoretical concepts and to gain practical skills. Different kinds of STEM projects have been implemented. Online virtual labs and data sets from physical laboratory experiments have been used for large-scale use in education (De Jong, Soteriou & Gillet, 2014). These labs offer the opportunity to students to perform scientific experiments with online labs in pedagogically structured learning spaces. Whitman and Witherspoon (2003) used LEGOs to interest high school students and improve k12 stem education.

Different kinds of enabling technologies and physical artefacts have been developed and have been applied to STEM learning projects. Microcontrollers, like Arduino (https://www.arduino.cc/en/Guide/Introduction), are popular in STEM education. Innovative projects have been developed using these devices. For example, a low cost educational robotics kit based on the UNO Arduino platform is discussed in (Junior et al., 2013). The prototype is used in secondary educational schools and is accompanied by documentation that addresses basic physics, mathematics, logic programming and robotics concepts. A low cost robotics system for educational purposes,

based on Raspberry Pi, has been used for teaching STEM concepts (Saleiro et al., 2013). Various Arduino projects have been created for grade levels ranging from grades 7-12 (Herger & Bodarky, 2015). Students have been engaged in basic elements of engineering and computer programming. In general, the introduction of the use of physical artefacts in the teaching of the curriculum of a Computer Science department has been successful in motivating and engaging the students, with a resultant improvement in student progression (Currie & James-Reynolds, 2017).

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs from sensors (digital and analog) and turn it into a digital output - activating a motor, turning on a LED, publishing something online, etc. Arduino has certain advantages from being inexpensive and cross platform to being extensible with additional shields, i.e. electronic boards implementing specialized operations like wifi communication. Arduino comes in different versions with different capabilities. Figure 1, shows an Arduino Uno board and Figure 2 a simple project with an Arduino Mega board.
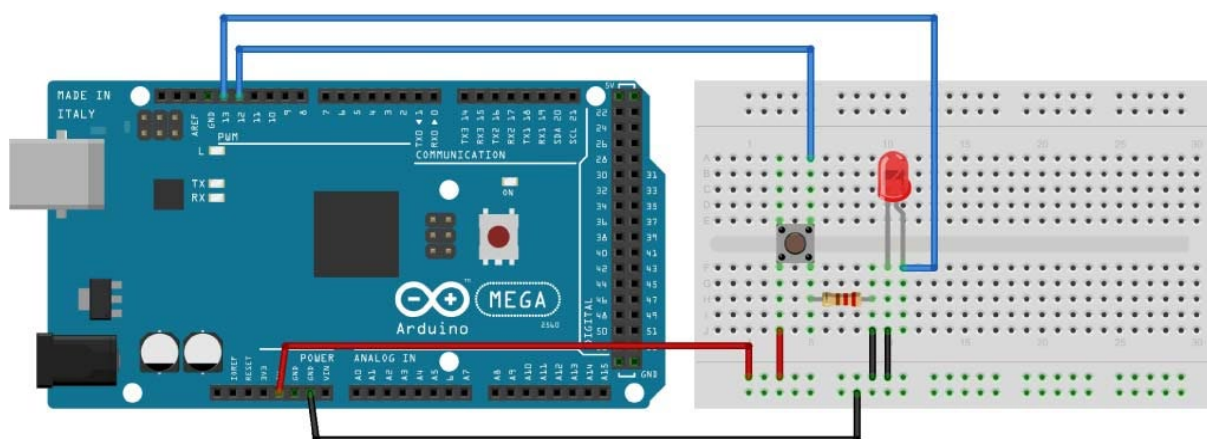

Figure 1: An Arduino uno microcontroller

Figure 2: A simple project with resistances, switches and led using Arduino mega

Arduino boards include analog ports for input from analog devices and digital ports for communication (input and output) from and to sensors and other devices. The inputs are processed by the code which is loaded on the board and suitable outputs are produced. The code is developed primarily in a C like programming language using the Arduino IDE, an open-source environment that helps users to write code and upload it to the board. That way different sensors and devices can be connected to Arduino and through coding they can be controlled to create complex systems.

In this work, we focus on helping students to develop Arduino projects through distance learning. In this way, we offer the opportunity to children that are educated in typical public school systems to acquire knowledge in microcontrollers and basic programming concepts. We describe our effort in the rest of the paper.

THE UNIVERSITY OUTREACH PROGRAM

The primary aim of our work was to engage students in Arduino projects in a time efficient mode. Through a university outreach program we aimed at teaching: *i.* Teachers and *ii.* Students of junior and senior high school (ages 12-18). It would be very demanding in terms of time and cost to run the outreach program in live face-to-face sessions. Hence, it was decided to run it in distance learning.

The literature has shown that MOOCs (Massive Open Online Courses) have a low completion rate, there is a lack of student support and interaction with other students and teachers, the teacher to student ratio is low (Eriksson, Adawi & Stöhr, 2017; Guo & Reinecke, 2014; Liyanagunawardena, Adams, & Williams, 2013). So we needed a more supportive structure which could also accommodate a large number of students. To achieve this aim we developed a blended learning course, which is a course consisting of:
- face-to-face meetings,
- online text (in html and pdf format),
- online asynchronous video lectures,
- synchronous sessions and
- focused and prompt support via forums and email.

The organization of the outreach program provides increased support to the participants so as to improve the completion rate and to support the needs of the learners.

An initial face-to-face meeting was held so as to:
- introduce the educational aims,
- showcase the Arduino kits,
- introduce the participants to the online platform,
- run together a project step by step,
- lend the Arduino kits (5 kits – boards with a set of sensors, leds and connection wires) to each school.

Figure 3: The structure of the e-course in Moodle

Then the participants have to study the online video lectures and to complete the activities. The course consists of units with specific objectives, video lectures, try-out activities and online tests and it has been developed in Moodle (see Figures 3 & 4), a popular open source Learning Management System suitable to manage its training content and allow for communication and interaction among students and teachers. The video lectures act as facilitators promoting self-learning, helping students to develop critical thinking skills. The try-out exercises, the quizzes and the assessment activities increase the active participation of the learners and follow a 'problem solving' approach. Easy or more difficult problems are posed, which require specific and measurable actions on behalf of the learners.

REALIZATION & EVALUATION OF THE COURSE
The material has been developed between November 2016 and March 2017 and the outreach activities have been deployed in 3 different streams involving various regional areas of Greece from March 2017 to December 2017. Each stream lasted 3 months and the participants were school classes, the students of which, with the help of a

local teacher, studied the online material. It would be difficult for individual students to participate as it would be difficult to distribute the Arduino kits. Therefore it was decided to include entire school classes. That way the Arduino projects would be followed by the school classes and implemented in a school class during school working hours with the help of their local teacher. This organizational model further improves the support to the students and it ensures that all the students will participate in the program. It also reduces the communication load as our support group communicates with only one person per school.

Figure 4: Examples of video and interactive activities of the Moodle course

A number of schools have been invited to follow this course and Arduino kits have been sent to them in order for the students to implement the practical activities. In total 10 schools, 223 students and 12 teachers have participated in the blended learning course. At least 10 projects per school have been implemented. Some new Arduino projects, as a result of the new acquired skills, have been realized. Students have enthusiastically completed all the activities with the aid of their teachers. After the course, they could better understand issues like the utility and importance of switches, resistors, capacitors and in general of the principles of electronic circuits.

CONCLUSIONS
In this paper we discuss a University outreach program with the aim to improve the understanding of STEM concepts of students. An e-course with teaching material (video lectures & interactive activities) about Arduino has been created. The program was run in a blended learning approach. In this mode we managed to effectively support the student groups and to help them complete all the tasks. Students were able to create a few electronic circuits and obtain practical skills. Based on the reports submitted by the participants, the students understood the role of components like resistances, switches, leds, and other sensors and the importance of correct connection of the components. They also did some programming using the Arduino programming environment.

We plan to repeat the activity during the next school year with some extensions and modifications to the learning material. More optional activities will be added, to maintain the interest of the most accomplished learners. To further improve the support towards new learners, we will engage teachers who have completed a previous run of the course, to help us, on a voluntary basis.

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