Physics teaching through Smart Cities

Sándor Gergely PESTHY, Mihály HÖMÖSTREI

ELTE University, Department of Materials Physics, Pázmány Péter sétány 1/a., 1117 Budapest, Hungary

Abstract. The technology of the future is not even fully known yet, but we must prepare our high school students for it. Using Arduino microcontrollers, we were able to teach the basic physics behind today's and partially tomorrow's technologies and to show how to use them in applications such as Smart Cities. Our project is economical and requires the creativity of our students. Using this creativity – and the well-planned guide of a teacher – our students can discover the connection between the programing and the actual physical realizations of the planned processes.

1 Why Arduino in physics education?

Different type of Arduinos are single-board microcontrollers and microcontroller kits for building digital devices that can sense and control objects in the physical world. The Arduinos are using typically dialects of C/C++ programming languages, what makes them suitable for high school IT education [1]. But using Arduinos is much more than programming itself.

The usage of bulbs, resistances, maybe coils or capacitors in electrical circuits is a must in high school but for most of the students it is not motivating enough to do further works and studies in this area of physics. Building so called "smart devices" can make this area much more attractive to students. To build any functional device with Arduino, students must get familiar on a good level with electrical circuits, which is already a notable result in physics education. For a more complex device, students must understand the physics behind the sensors and the phenomena themselves.

Arduino controllers are obviously usable for measurements too, what makes physics more understandable and more usable. But Arduino can be used for even more: it can improve the structured, logical, well planned and observation-based way of thinking of our students.

2 "Ordinary" students in a special project

2.1 Our Students

The students of the German Nationality High School are not specially selected students. The main focus of the school is the German language and folklore. But even in this non-STEM school it is possible to find a high number of interested and motivated students in physics and technology. In our study group the students are working once a week after the regular lessons, sometimes until the early evening.

Beside the internal motivation of the students the reason for such a high amount of work is the freedom of the applied project method. Our students are working in two or three-person groups, so after introductory phases of the lesson they can work in their own speed and depth of knowledge. In the project we can be flexible to cover the very wide spectrum of our students, who are between the 9^{th} and 12^{th} grade.

2.2 Our project

Our students are working in pairs or triplets what makes their work not only more enjoyable but helps them to develop the required skills to work in group also. Our lessons start always with a short lecture about the physical backgrounds of the used device, which is followed by playful usage of the newly learned knowledge.

After they became familiar with the physical background we focus on building circuits and programming. The required and used programming language by the students gets more complex from lesson to lesson, but even from task to task within one lesson. The basic tasks of our project are based on German and American models [2,3] and we evolved it with our colleagues from Georg-Cantor-Gymnasium Halle, Germany. These steps were improved for our special requirements of the Hungarian physics curriculum and for the improvement of the creativity of our students. This creativity let our students to design and create their own ideas for a Smart City at the end of the academic year.

It is very important for us to check our effectiveness on all our projects. This applies to examining the quality and quantity of the knowledge transferred and assessing students' satisfaction. The effectiveness of knowledge transfer is tested by pre and post testing based on a methodology developed by us.

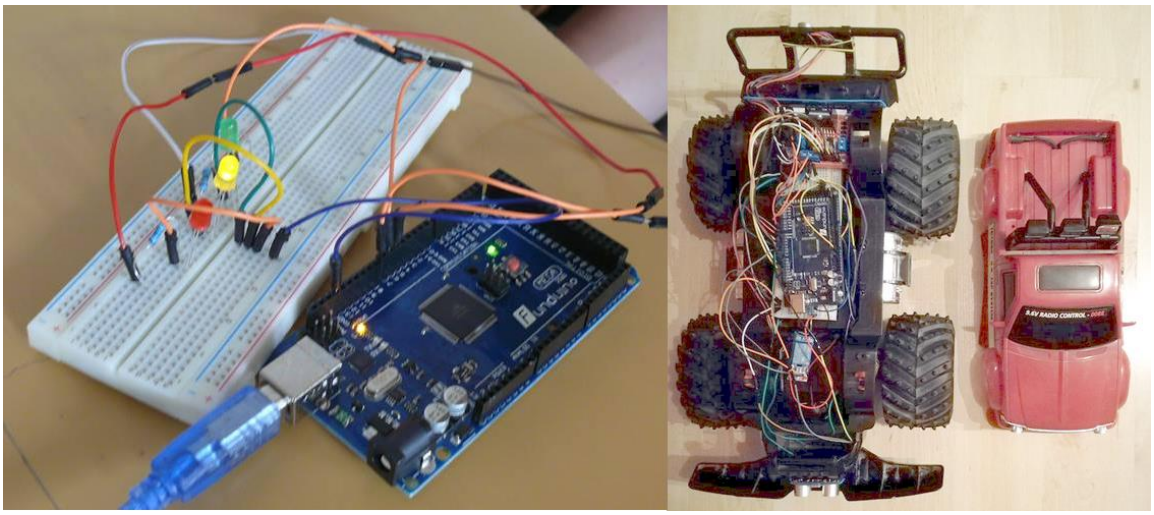

Fig. 1.: Model of traffic lights as a simple start of the project (left) , and a Smart Car on intermediate level (right)

3 Conclusion

Physical background of sensors and everyday physics, electrical circuits, programming. These knowledges are essential in the 21st century and all of them can be improved by using Arduinos in high school. But what maybe even more important is, during our project, our students learned how to work as a part of a team and got an insight into the way how scientists or engineers think, while they had a great time and realized their ideas!

References

[1] Internet: https://en.wikipedia.org/wiki/Arduino
[2] Internet: https://funduino.de
[3] Dr. John E. Post: An Arduino-Based Summer Camp Experience for High School Students ASEE's 123rd Annual Conference & Exposition, New Orleans, LA, 2016