A Survey with Primary School students on the use of an Arduino-Uno based pyranometer and the temperature gauge

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Abstract. This paper focuses on a teaching intervention on the measurement of temperature and the intensity of solar radiation, by the students, accompanied by a survey with anonymous questionnaires. The sample consisted of students of the last grade of the Greek Primary school (grade 6). The didactic intervention and the measurement of the solar radiation and the temperature are carried out through an Arduino Uno and an Arduino Nano Ble arrangement. After the teaching intervention, through the provision of pre-test and post-test, the students' ability to describe and measure the concept of solar radiation and temperature is recorded and evaluated.

Introduction

According to the literature, students find it difficult to understand the concepts of solar radiation and temperature, as they cannot easily approach and perceive them with their senses [1]. To resolve this issue, devices based on natural programming were created, in order to measure the two quantities, solar radiation (pyranometer), and temperature. The pyranometer is a device that measures solar radiation (W/m^2) [2]. The basis of the pyranometer is the Arduino Uno micro-controller and other compatible components such as a breadboard, resistors, jumper wires and a 5V battery (Figure 1). The created pyranometer tool has been published within the Arduino Project Hub platform (https://projecthub.arduino.cc/zogrpapan/measuring-solar-radiation-with-a-pyranometer-527ede). In addition, as regards the temperature measurement, the Arduino Nano BLE was utilized, which enables wireless recording of the measurements on the mobile phone via Bluetooth.

Theoretical framework and research questions

The use of microcontrollers allows the visualisation of concepts and enables them to be explored in an easy and friendly way, by students independently [3]. Students' views are recorded through a questionnaire (Pre-test) before the teaching intervention. The questionnaire contained closed-ended questions on a Likert scale. After a short theoretical presentation of the concepts, the students then measured the temperature and solar radiation in different parts of their school. The field measurements allowed them to interact and exchange views on the phenomenon [3]. In order to test the contribution of the intervention to the understanding of the nature of solar radiation and its propagation, a similar questionnaire was given after the end of the teaching intervention to observe any changes in the students' views (Post-test). The research questions of this study are: (i) what is the extent of usability of the Arduino Nano BLE based pyranometer and temperature gauge device for elementary school students? (ii) what is the extent to which these devices can be used to approach the concept of solar radiation and dispel misconceptions about solar radiation, temperature and their properties? [4].

Methods and findings

The investigation on the concepts of intensity of solar radiation and of temperature is carried out through an anonymous questionnaire distributed to public Primary School students. Eighteen (N = 18) students were the sample of the survey. Within the question "I Know what a pyranometer is", prior to the activity, 11 students responded that they did not know (answer: “not at all”) the pyranometer. Finally, no student stated that they know very well (answer: “very well”) the identity of the tool. After the implementation of the teaching intervention, changes in the opinions of the sample students were observed, with 10 students knowing very well what the pyranometer tool is. The positive responses of the students' knowledge after the intervention can reveal the effectiveness of the intervention. Through the measurement activity, the students had the opportunity to get in touch with solar radiation, temperature and its measurement based on certain units of measurement, which they did not know before. Arduino-based tools proved to be very useful in understanding the concepts.

Regarding the question "I can easily measure the temperature with a robot", before the implementation of the teaching intervention 7 students stated that they can (answer very well) easily measure solar radiation with a robotic device, while 6 students stated "a little" in the question about the ability to measure the temperature with a robot. In addition, 3 students stated "rather" to this question, and 2 students stated "not at all". After the instructional intervention, 11 students stated very capable to measure temperature (answer very much) with a robot, while 6 stated "rather". Through the students' responses, the usefulness of the devices for measuring solar radiation and temperature became apparent, as well as students gaining confidence in independently measuring the two quantities and overcoming any misconceptions. Also, 17 of the students said they liked the activity with a response of very much or rather.

Conclusion

Despite the limitations of this research, such as the small sample used and the limited teaching time dedicated, it was possible to obtain feedback from the student community on the measurement tools. Therefore, through the present research, an attempt was made to investigate the contribution of physical-programming-based Educational Robotics’ instruments (Arduino Uno and Arduino Nano BLE microcontrollers) to the acquisition of the concepts of temperature and solar radiation and their accurate measurement. It was observed that the usability of the Arduino Nano BLE, as well as and the pyranometer devices was high and it also became evident that the devices can be used to visualize the concept of solar radiation and temperature to young students. Through the responses, it was observed that the students after the teaching intervention had the perception that they could measure solar radiation and temperature through tools and knew what a pyranometer was to a much greater extent than before the teaching intervention. In addition, through data acquisition and field measurement, students were able to develop problem solving skills [5].The views expressed by the students and their comments can be used in the future, in order to draw general conclusions about the effectiveness of the aforementioned tools.

References

[1] A. Mandrikas, K. Tabakis, M. Tsilidis, A. Chalkidis, P. Psomiadis, K. Chalkia, K. Skordoulis, Students' perceptions of ozone as a factor in designing educational software for environmental education. In Th.D. Lekkas (ed.) *Proceedings of the 2nd Conference on School Environmental Education Programs.* Athens, 2006.

[2] P. Dimitrentsis, M. Mitsioni, H. Pipis and T. Chatzimbekiaris, *Measurement of albedo and emissivity of bodies using home-made electronic instruments*. Can Sat Greece (2013).

[3] S. Psycharis and K. Kalovrektis. *Didactics and Design of STEM & ICT Educational Activities*. Thessaloniki, Greece, 2018.

[4] K. Pandey and K. Katiyar. Solar radiation: Models and measurement techniques, *Journal of Energy* (2013).

[5] K. Skordoulis and M. Sotirakou, *Environment, Science and Education*, Athens, Greece, 2005.