The Influence of Using an Arduino-supported Project Book on the Development of Knowledge and Attitude towards Physics

Dorottya SCHNIDER (1, 2), Mihály HÖMÖSTREI (1, 3)

(1) Eötvös Loránd University, Faculty of Science, Institute of Physics, Department of Materials Physics, Pázmány Péter sétány 1/A, H-1117 Budapest, Hungary
(2) Fazekas Mihály Primary and Secondary School, Horváth Mihály tér 8, H-1082 Budapest, Hungary
(3) Deutsche Schule Budapest, Cinege út 8/C, H-1121 Budapest, Hungary

Abstract. In our study, we offer secondary school physics teachers an insight into the effective application of Arduino-based classroom measurements for teaching kinematics. We introduce our Arduino-supported workbook, which contains Arduino-based kinematics measurements with the use of an ultrasonic wave sensor. The aim of the tasks is to develop students' knowledge and professional skills, e.g.: data processing, data analysis, interpretation, graphical representation, etc. In our study, we investigated the role of Arduino measurement tasks in knowledge, competence, and attitude development of 7th grader students. The results indicate the positive effect of well-coordinated, practice-oriented, and creative activities in the classroom.

Introduction

Due to rapid technological advancements and economic changes, education needs to adapt to altered circumstances. Access to a wealth of knowledge anytime through the internet requires education to emphasize critical analysis and application skills that remain effective in a changing environment. The purpose of PISA assessments [1] is to examine how well students can apply their knowledge. Therefore, education should focus on developing competencies, such as interpreting phenomena, evaluating data, problem-solving, effective communication, and succeeding in the professional world. Encouraging students to not only passively listen to lectures but also actively explore subject matter through hands-on activities triggers psychomotor processes, ensuring better retention and practical application of the information [2].

In this paper, we introduce a way of teaching *kinematics* throughout Arduino-based by worksheets, which connects physics, pedagogy, and technology *(TPACK)* [3], and we investigate its effects on students' scientific competencies and their attitude towards learning the subject.

Objectives

One possible way to enhance students' in-class participation is the application of classroom measurements. Arduino-based measurement projects conducted by small groups of students under the supervision of the teacher contribute to knowledge, competency, and attitude development. Numerous best practices and educational ideas related to Arduino can be found online. In our current study, we aim to present an educational package we developed – Arduino workbook [4] to teach *kinematics* based on our *Competence-based physics teaching* methodology [5], focusing on kinematics learning through Arduino-supported student measurements. The package includes measurement instructions, supporting illustrations, and tasks related to the measurement (e.g., explaining the phenomenon, evaluation, and the development of scientific digital competencies, too [6]). To investigate the influence of the mentioned activities on students' skills and attitude we carried out research among our students based on the following research questions:

(1) What is the influence of conducting Arduino-supported classroom measurements on the development of 7th graders' *kinematics* knowledge and scientific competencies?

(2) What is the opinion of students about physics teaching-learning methods? What role does the applied method play in the students' assessment of individual activities?

Methods and findings

During our investigation, we designed a 4-lesson-long project for 7th graders and conducted research among about 50 students – experimental and control group. The experimental group had the opportunity to practice kinematics by solving tasks from the Arduino workbook. Students used the Arduino-operated ultrasonic wave sensor for gathering data, then they represented data graphically and analysed the graphs. In contrast, students in the control group practiced kinematics in a traditional manner, primarily through calculation tasks, although they also encountered more engaging tasks, such as simulations and games. To evaluate students' performance and investigate the differences between experimental and control group, we used a pre-, post- and follow-up test including PISA and other application-oriented tasks. Students with similar prior knowledge showed a notable improvement in kinematics by the end of the project. Members of the experimental group performed significantly better on calculation tasks, and their results on the follow-up test conducted two months later were also markedly superior to those of the control group. Finally, both groups were asked to complete a questionnaire, evaluating the methods related to learning physics. The results indicate that regardless of the students' group affiliation, they express a preference for interactive activities, student measurements, more relaxed and playful tasks, and find the use of digital tools interesting in physics class. Moreover, students in the experimental group find physics interesting and willingly engage with it, which can be considered a positive outcome of the method.

Conclusion

In our study, we present an educational resource that enables active involvement of students in physics class by carrying out measurement activities. The worksheets supporting classroom measurements ensure that students learning physics at a basic level acquire in-depth knowledge in the topic of kinematics. Simultaneously, they learn to operate the data collector and confidently work with data - evaluating, analyzing, and explaining. Based on the results of our study, the method is not only beneficial for knowledge and competency development. Practice-oriented student activities also contribute to enhancing attitudes towards physics.

References

[1] OECD. (2022). PISA results. https://doi.org/10.1787/53f23881-en

[2] C. Hannaford, *Smart Moves: Why Learning Is Not All In Your Head*, Arlington VA: Great Ocean Publishers. 1995.

[3] S. Kurt, TPACK: Technological Pedagogical Content Knowledge Framework, Educational Technology(2019, September 16). https://educationaltechnology.net/technological-pedagogical-content-knowledge-tpack-framework/

[4] D. Schnider and M. Hömöstrei, *Kinematics exercises with Arduino. Measurement and graphic exercises for preparatory physics lessons*, 2023. https://schniderdorottya.com/arduino-feladatlapok-pdf#6cbb54ee-61fd-4b9b-b9de-1bd46689265e

[5] D. Schnider and M. Hömöstrei, *The Influence of Arduino-based Student Experimentation on the Development of Students' Skills and Competences*, 2023. https://doi.org/10.1007/978-3-031-44312-1_14

[6] © 2020 Workgroup Digital Core Competencies. http://dikolan.de/