

HANDS-ON PHYSICS: EXPERIMENTAL TEACHING FROM PRIMARY TO TERTIARY EDUCATION

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Abstract

The Erasmus+ project “Lexicon of STEM Educational Films for Primary and Secondary School Students” (Films4Edu) aimed to enhance the quality and reach of distance education in STEM disciplines at the primary and secondary school levels. Implemented across four countries and six partner institutions: University of Silesia in Katowice (Poland), University of Innsbruck (Austria), University of Málaga (Spain), Children’s University of Malopolska Foundation (Poland), AGH University of Science and Technology (Poland), and the University of Žilina (Slovakia), the project focused on developing innovative audiovisual teaching resources.

This contribution presents selected educational videos produced at the University of Žilina and examines their potential integration into STEM curricula in primary and secondary education.

We are currently continuing our work within the new Erasmus+ project “Experiments for Better Teaching in Higher Education” (expEDU). The project aims to foster more interconnected higher education systems by building an international community of science educators who collaboratively share knowledge, resources, experiences, and best practices in physics experimentation. This collaborative framework strengthens the capacity of partner institutions to work more effectively together, ultimately contributing to improved educational outcomes. The main priority of the project is to stimulate innovation in teaching and learning by supporting pedagogical experiments and introducing new approaches to teaching in higher education.

During the presentation, we will outline the project's objectives, explore opportunities for further cooperation, and discuss ways to participate in the initiative. In addition to the University of Žilina (UNIZA, Slovakia), the participating institutions include the University of Silesia in Katowice (Poland), VSB – Technical University of Ostrava (Czech Republic), and Ivan Franko National University of Lviv (Ukraine).

Keywords: *STEM education, interactive teaching of physics, educational films, Films4Edu, expEDU.*

1. Introduction

The specific objectives of the Films4Edu project were to enhance the knowledge and competencies of primary and secondary school teachers in the use of film-based experimental approaches in STEM education; to increase primary and secondary school students’ interest in physics and chemistry experiments; to strengthen the understanding of dissemination activity beneficiaries regarding the educational opportunities afforded by film-based experimental methodologies in STEM; and to foster innovation and internationalization among the six participating institutions through the exchange of best practices, the joint development of universally applicable educational and training materials, and the promotion of open education.

2. Methodology

The project produced several intellectual outputs, including a *Methodology for Teaching STEM Subjects through Film4Edu Experiments*, an *Online Catalogue of Physics Experiments for Primary and Secondary Schools*, and an *Online Catalogue of Chemistry Experiments for Primary and Secondary Schools*. The developed scenarios highlight two primary functions of experiments: a methodological function, whereby experiments serve as a source of knowledge and a means of verification, and a didactic function, encompassing introductory experiments designed to create problem-based learning situations,

cognitive experiments that facilitate knowledge acquisition, verification experiments used to test hypotheses, and illustrative experiments aimed at demonstrating phenomena and validating scientific laws.

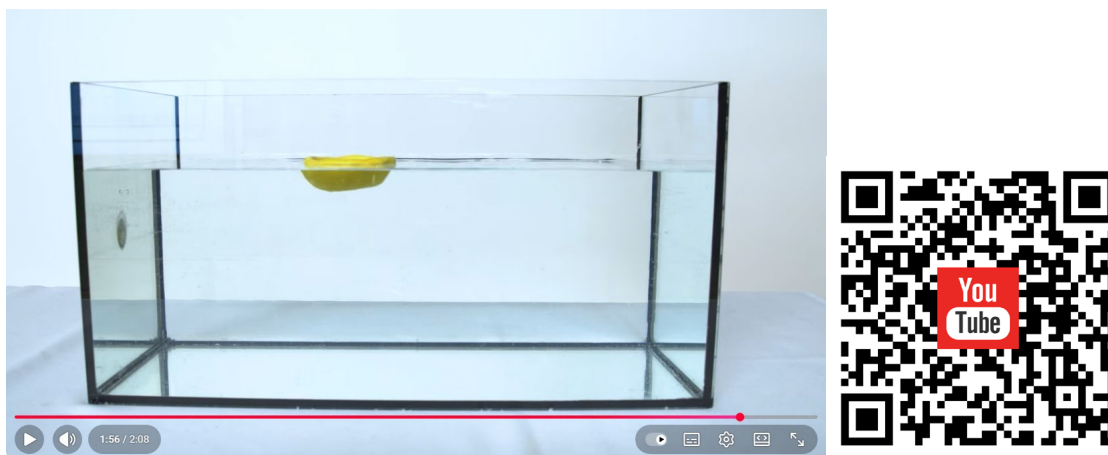
3. Results

As an outcome of the project, European primary and secondary school teachers gained access to a comprehensive collection of didactic videos presenting physics and chemistry experiments, which can be integrated into face-to-face instruction as well as online teaching environments. For each recorded experiment, an accompanying worksheet was developed, providing a detailed description of the experimental procedure, a scientific explanation of the underlying physical or chemical phenomena, and a clear indication of the target educational level. In addition, each video is supplemented with formative assessment questions that enable teachers to evaluate students' conceptual understanding of the experimental principles. Overall, the project resulted in the production of more than 100 didactic videos in physics and chemistry, which are publicly available through the Films4Edu YouTube channel: <https://www.youtube.com/@films4edu607/videos>.

3.1. Floating objects - one of 100 experiments and videos from Films4Edu

The primary objectives of this video (Figure 1) are to analyze the physical properties of liquids and to facilitate conceptual understanding of Archimedes' principle. The experiment is motivated by the observation of natural phenomena, such as bodies floating on or sinking in a liquid. The instructional focus is on elucidating the conditions under which an object floats or sinks, identifying the parameters that determine the magnitude of the buoyant force, and examining the possibility of objects with densities greater than that of water remaining afloat on the liquid surface. The video has a duration of 2 min 8 s and is available on the Films4Edu YouTube channel: https://youtu.be/9mCHM2_G6IE.

Figure 1. Films4Edu video - Floating Objects | FLUIDS and QR code for more videos.



4. Discussion

Information and communication technologies (ICT) in physics education contribute significantly to enhancing the effectiveness of the teaching and learning process. Motivation to engage in STEM (Science, Technology, Engineering, and Mathematics) disciplines typically emerges during primary education or earlier; therefore, early intervention is essential for achieving positive long-term educational outcomes. In response to this need, the Children's University of Žilina (CUZ) has been implemented as a summer educational program for primary school pupils. Questionnaire-based feedback from participating children indicates a strong demand for a greater number of experimental demonstrations, more extensive use of multimedia resources, and instructional approaches that foster imagination, creativity, and collaborative skills (Hockicko et al., 2020, 2025). Developing students' imaginative capacity and analytical thinking has been shown to enhance interest in natural sciences and technological subjects (Hockicko et al., 2025). Within this context, teachers and researchers from the University of Žilina have sought to stimulate young learners' motivation for future studies in science and technology through the organization and delivery of the Children's University of Žilina (Figure 2).

Figure 2. Experimental activities implemented during the Children's University of Žilina after watching the video.



As reported in our previous study (Hockicko et al., 2020, 2025), analysis of questionnaires completed by children over 15 years of the CUZ summer program indicated that primary school students prefer lessons that are more playful, include a greater number of practical demonstrations and experiments, and provide opportunities for hands-on laboratory activities, with 47% (Hockicko et al., 2020, (46% (Hockicko et al., 2025)) of respondents expressing interest in conducting experiments independently.

The educational videos developed within the Films4Edu project have the potential to further motivate young students to engage in experimental activities and serve as a valuable resource for primary and secondary school teachers in designing and implementing effective, student-centered laboratory exercises.

The new project expEDU seeks to enhance the integration of higher education systems through the establishment of an international network of science educators dedicated to the exchange of knowledge, resources, experiences, and best practices in physics and chemistry experimentation. This collaborative framework strengthens inter-institutional cooperation and improves the collective capacity of partner institutions to implement effective educational strategies, thereby contributing to enhanced learning outcomes. A central objective of the project is to promote innovation in teaching and learning by supporting pedagogical experimentation and the adoption of novel instructional approaches in higher education. As a key output, the project will produce 80 experimental physics and chemistry video resources, accompanied by comprehensive instructional guidelines for educators and made available in multiple languages.

5. Conclusions

Empirical evidence indicates that the use of instructional videos demonstrating fundamental physics concepts, when complemented by video analysis and guided discussion, leads to significant improvements in students' conceptual understanding and knowledge acquisition in Newtonian mechanics. Consequently, we are continuing to develop additional instructional videos aimed at further enhancing the effectiveness of physics instruction in higher education.

Acknowledgments

This work was supported by the Slovak grant agency KEGA through projects no. 006ŽU-4/2024, no. 003TU Z-4/2024 and the Grant Agreement no. 2025-1-PL01-KA220-HED-000363551 co-funded by the European Union.

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