# Factors of quality of physics demonstrations

Alexandr NIKITIN, Marie SNĚTINOVÁ, Petr KÁCOVSKÝ

*Department of Physics Education, Faculty of Mathematics and Physics, Charles University, V Holešovičkách 2, 180 00, Prague, Czech Republic*

**Abstract.** This paper describes a video study of physics demonstrations for upper secondary school students from the perspective of parties relevant in physics education – physics teacher trainers, pre-service physics teachers, in-service physics teachers and upper-secondary students. The video-recordings of the performances are divided into numerous short sections, which are evaluated on prepared rating scales. Results show that the overall impression of short sections is mainly influenced by the atmosphere in the auditorium. Other relevant factors are the clarity of lecturer's speech and the clarity of experiments. These factors explain about 85% of the variance in the overall impression of these sections.

## Introduction

Our department organizes *Physics demonstrations for upper secondary students* (DEMOs) – an out-of-school activity consisting of a carefully thought-out series of physics experiments. DEMOs offer seven different physics topics performed frontally by one or two lecturers.

Data from previous research [1] showed that different topics are perceived differently by the students. The question arises as to what factors in these performances may account for these differences. In this contribution, we only investigate the relationship between parameters of short experimental sections from these shows.

## Theory and methodology

Experimentation is the cornerstone of physics education. Although some researchers have suggested that demonstration experiments have a negligible effect on student achievement [2], other studies suggest that demonstrations – when done correctly – can increase student understanding [3] and can also "jump-start" student interest in the field [4].. It is for this reason that demonstration experiments are worthy of research attention.

The research design can be methodologically described as an expert observation, more specifically a video study using rating scales. In the 2017/2018 school year, a video recording was made of each performance. These video recordings were divided into a series of approximately 6-minute short sections. There are 100 sections in total.

84 respondents were evenly divided into four groups – upper-secondary students, upper-secondary physics teachers, pre-service physics teachers and physics teacher trainers. Each respondent was given 11 short sections and one full performance to rate. Only short sections are discussed further; for details on the research design, one can refer to [5].

Each short section is rated on five 5-level scales with detailed verbal descriptions of levels 1, 3 and 5. A verbal commentary can be added to each scale, which is mandatory for the selection of levels 2-4. The scales used are the *overall impression of the lecturer's performance*, the *atmosphere in the auditorium*, the *clarity of speech*, the *clarity of experiments* and the *visibility of experiments*.

## Results

The correlations between the scales indicate that there is a very strong relationship between the overall impression for a given section and the atmosphere in the auditorium ($r^2 = .82$). In contrast,

the visibility of the experiments does not correlate well with the other scales. The reliability analysis of these four scales suggests that it is appropriate to omit this scale from further analyses. After omitting it, the Cronbach's $\alpha = .90$.

The remaining four scales were analysed using a linear model with the overall impression of lecturer's performance as the dependent variable ($R^2_{adj} = .85$). Based on the *p*-values for the individual coefficients of this model, it can be said that the atmosphere in the auditorium ($p < .01$), the clarity of the speech ($p < .01$), and the clarity of the experiments ($p = .03$) are all significant factors affecting the overall impression of the short sections at the .05 level.

## Discussion and conclusions

Our data suggest that the most important factor influencing the overall impression of frontally presented experiments is the atmosphere in the auditorium. This scale strongly relates to the lecturer's interaction with the audience during these shows, which has already been analysed using a categorical system of behaviours [6].

The linear model suggests that over 80% of the variability in the overall impression of these short sections can be explained by the atmosphere in the auditorium, the clarity of the lecturer's speech, and the clarity of demonstrated experiments.

It should be noted here that this is the overall impression elicited in our raters, not in the students attending DEMOs. Since a research investigation has been conducted on the latter to investigate their perceptions of these performances [1], relating data from these investigations can provide very interesting insights into the issue of physics demonstrations, especially when combined with qualitative data from the qualitative open-ended responses and results for whole performances.

## References


[1] P. Kácovský and M. Snětinová, Physics demonstrations: who are the students appreciating them?, *International journal of science education* **43**(4) (2021) 529-551.

[2] C. Crouch, A. P. Fagen, J. P. Callan, E. Mazur, Classroom demonstrations: Learning tools or entertainment?, *American Journal of Physics* **72**(6) (2004) 835-838.

[3] S. Basheer, M. Hugerat, N. Kortam, A. Hofstein, The Effectiveness of Teachers' Use of Demonstrations for Enhancing Students' Understanding of and Attitudes to Learning the Oxidation-Reduction Concept, *Eurasia Journal of Mathematics, Science and Technology Education* **13**(3) (2017) 555.

[4] H. Lin, Z. Hong, Y. Chen, Exploring the Development of College Students' Situational Interest in Learning Science, *International Journal of Science Education* **35**(13) (2013) 2152-2173.

[5] A. Nikitin, D. Mandikova, I. Pavelkova, M. Chval, M. Snetinova, P. Kacovsky, *Design of a Research on Students' Perception of Physics Demonstrations.* In J. Pavlů & J. Šafránková (Eds.), WDS'22 "Week of doctoral students 2022": 31st annual conference of doctoral students, Faculty of Mathematics and Physics, Charles University, Czech Republic, June 7 to June 9, 2022. Physics (pp. 222-225). Matfyzpress.

[6] A. Nikitin, Fyzikální pokusy pro střední školy – videostudie. [Physics demonstrations for upper secondary school students - a video study] Rigorous thesis (RNDr.). Univerzita Karlova. Matematicko-fyzikální fakulta, 2023.