Measuring the quality of instruction in physics education using free modern cloud technologies

Peter STRAUCH, Jozef HANC

Institute of Physics, P.J. Safarik University in Kosice, Park Angelinum 9, 040 01 Kosice, Slovakia

Abstract. We will present the results of our research on the quality of Slovak students' conceptual understanding in mechanics at the secondary school level. In the research, where sampling was based on PISA (TIMSS) stratified two-stage cluster sample procedure, we are applying the well-known Force Concept Inventory, a research-based diagnostic content survey, together with the free modern cloud technologies - the electronic forms (Google forms) and the interactive cloud computing tools (Jupyter, R Shiny). Our up-to-date experience also shows that due to the technology collecting data and their statistical analysis is less technical, time-consuming and more reproducible than before.

1 Measuring conceptual understanding in physics

The efficiency of any education is significantly affected by prior knowledge, understanding and experience of students on what they learn [1, 2]. Therefore, one of the key characteristics of physics instruction evaluation and instruction quality is students' conceptual understanding. Every competent teacher should have skills and tools to diagnose the incorrect preconceptions or misconceptions. In physics education research, we can quantitatively measure students' conceptual understanding through research-based content surveys or conceptual tests [3], whose number is currently almost fifty (https://www.physport.org/).

2 Reproducible research with free modern cloud technologies

Administrating conceptual tests even in a classroom by standard collecting or processing methods is still time-consuming, using more advanced methods is too difficult to carry out or reproduce. In our research, we are testing new interactive cloud-based technologies – the electronic forms (Google forms) for data collection, Jupyter notebooks [4] and an R Shiny app [5-7] for data processing. As for research questions, we are finding answers to following pedagogical problems: *Are mentioned tools directly and easily applicable in school conditions? Using these technologies, can we estimate the quality of the conceptual understanding of Slovak students at secondary schools in chosen physics area (mechanics) in reasonable short time and with low costs?*

Our pilot study on trial samples indicates positive answers to these questions. At the time of conference talk, we will refer our experience and quality measurements based on Force concept inventory [8, 9] applied to a representative national sample from Slovakia chosen by us using PISA (TIMSS) stratified two-stage cluster sample procedure [10, 11].

3 Preliminary conclusions

Thanks to the free modern cloud technologies for data collecting and processing from diagnostic tools, pedagogical research or feedback should be less technical and time-consuming than before. Our pilot experience also indicates that Jupyter notebooks are more appropriate for the efficient and easily reproducible research work of scientists, didactic research groups or students during their diploma thesis or dissertation research. On the other hand, the interactive R Shiny application (Fig.1) providing visually rich, one-click statistics is ideal for in-service

teachers who need easy-to-handle, quick-to-use and no time-consuming processing of collected data, as well as their interpretation with recommendations.

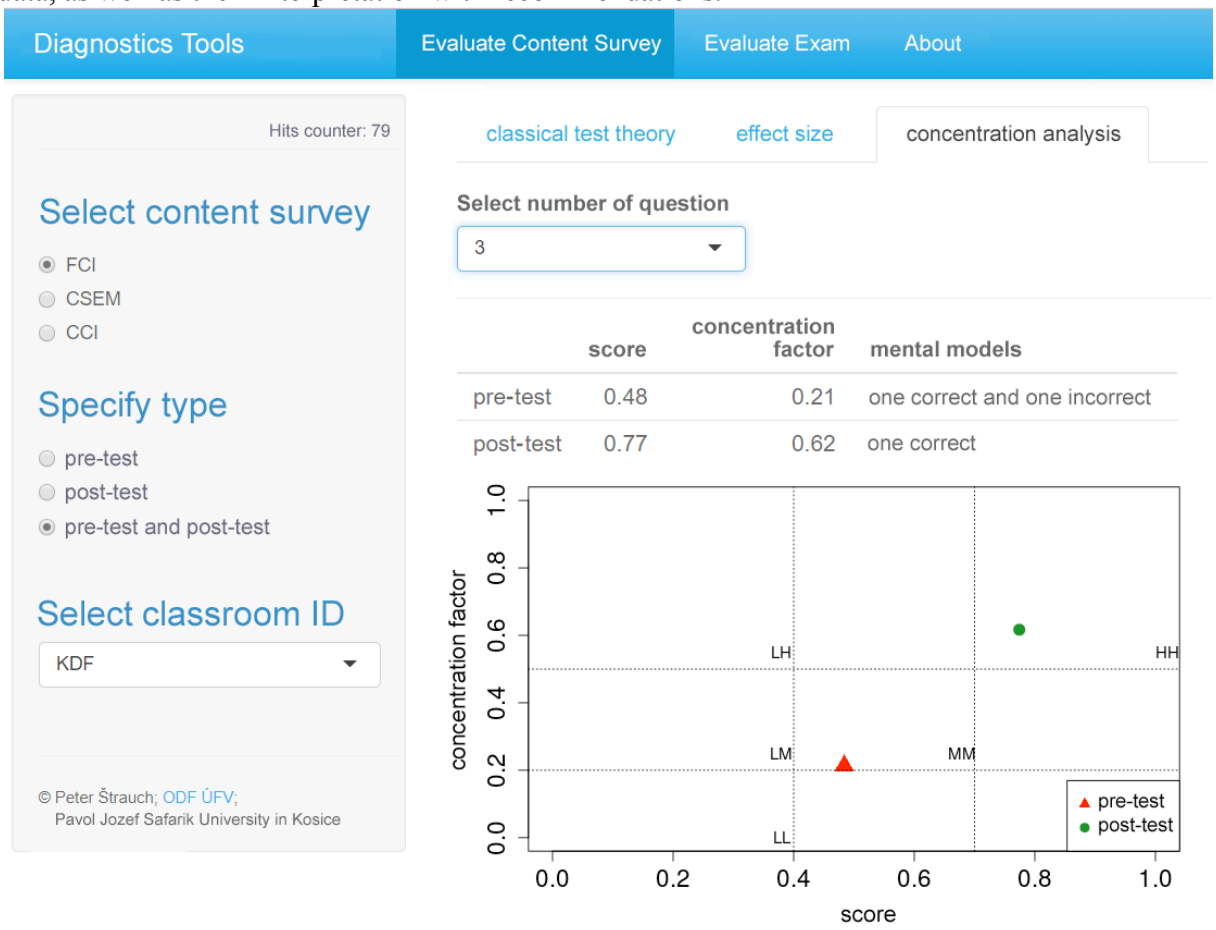

Fig. 1 A screenshot of our Shiny application with similar functionality as the Data Explorer at https://www.physport.org, providing quick informative one-click statistics from chosen diagnostic tools

References

[1] J. Hattie, The applicability of Visible Learning to higher education. *Scholarsh. Teach. Learn. Psychol.* **1** (2015) 79–91.

[2] E. F. Redish, Oersted Lecture 2013: How should we think about how our students think?, *Am. J. Phys.* **82** (2014) 537–551.

[3] A. Madsen et al., Resource Letter RBAI-1: Research-Based Assessment Instruments in Physics and Astronomy, *Am. J. Phys.* **85** (2017) 245–264.

[4] T. Kluyver et al. Jupyter Notebooks – A Publishing Format for Reproducible Computational Workflows. In F. Loizides, B. Schmidt (eds.), *Proc. of the 20th Int. Conf. on Electronic Publishing*, IOS Press, Amsterdam, 87–90, 2016.

[5] R. M. Heiberger, B. Holland, Shiny: Web-Based Access to R Functions. In *Statistical Analysis and Data Display: An Intermediate Course with Examples in R*, Springer, New York, 743–747, 2015.

[6] R Core Team. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing: Vienna, Austria, 2017, http://www.r-project.org/.

[7] T. Verbeke et al. (eds), *The R User Conference, useR! 2017 - Book of Abstracts* [online], Open Analytics NV, Antwerp, 2018, https://www.user2017.brussels/.

[8] D. Hestenes et al., Force concept inventory, Phys. Teach. 30 (1992) 141–58.

[9] J. Von Korff et al., Secondary analysis of teaching methods in introductory physics: A 50 k-student study, *Am. J. Phys.* **84** (2016) 969–974.

[10] M. O. Martin et al. (eds), *Methods and Procedures in TIMSS 2015*, TIMSS & PIRLS International Study Center, Boston, 2016.

[11] OECD, *PISA 2015 Results (Volume I): Excellence and Equity in Education* [Online], OECD Publishing, Paris, 2016, http://www.oecd-ilibrary.org/content/book/9789264266490-en.