2019 5th Experiment@ International Conference (exp.at'19)
June 12th – 14th, 2019, University of Madeira, Funchal, Madeira, Portugal

# Dynamic Repository of Experimental Results

Saša Gavrilović
National Bank of Serbia, Faculty of Engineering at University of Kragujevac
Kragujevac, Serbia
email address: sasa.gavrilovic@nbs.rs

Jovan Kovačević
Faculty of Engineering at University of Kragujevac
Kragujevac, Serbia
email address: koca.kg.996@gmail.com

Milan Matijević
Faculty of Engineering at University of Kragujevac
Kragujevac, Serbia
email address: matijevic@kg.ac.rs

***Abstract*— This work presents the content and structure of designed web portal for supporting to dynamic repository of experimental results which are organized for engineering education purpose. The most illustrative experimental results for demonstration of relevant phenomena in engineering education are organized through I/O data and sets of short video clips and diagrams per one experiment. Namely, a realization of a laboratory experiment is divided into short time sequences or phases of laboratory exercise, but their monitoring can be organized jointly or/and separately. At the same time, all phases of a laboratory exercise are demonstrated. At this manner, a beneficiary can understand demonstration of a laboratory exercise much faster and more completely. Moreover, the approach to the web site is individualized, and a beneficiary can choose one of the offered sets of parameters for experimental realization. One experimental realization means approach to real experimental data (which are consisting of experimental parameters and experimental measurements) and visualization of experimental data through supervision via diagrams and videos. Beneficiaries can activate a few experiments in order to compare experimental results with different experimental parameters. The site includes appropriate guides and contents for basic theory, descriptions of experimental setups, and problem-based education.**

***Keywords—engineering education, open educational resources, shared experimental results, virtual laboratories***

## I. Introduction

Experiments are necessary part of engineering education. However, hands-on laboratories for engineering education as well as available experimental installations are very limited resource everywhere. Some of limitations in the use of hands-on laboratories are trained staff and defined schedule of laboratory classes, also. This problem can be overcome by using virtual laboratories and/or Internet-mediated laboratories with defined experimental protocols and all relevant descriptions and tutorials. Laboratory exercises via the Internet are one way of sharing laboratory resources in order to increase the availability of experimental work. However, there are many situations that use of Internet-mediated laboratories are non-realistic. In addition, virtual laboratories are not enough realistic, but they are illustrative and useful teaching and learning tools. Because of that, in [1] is proposed problem-oriented engineering education based on shared experimental results. Namely, in [1] are described needs, possibilities and implementation of open educational resources which are supporting the problem-oriented engineering education based on realistic experimental results. Experimental results can partly substitute real experimentation which is a necessary part of engineering education and research [2-4]. Open educational resources and use of blended learning approach can improve relevancy and decrease costs of engineering education for majority of engineering schools [5-6]. Like in [7], eexperimental datasets or repositories of experimental results can be published and to be citable.

This paper demonstrates web portal based on realistic experimental data which offers 1) download of datasets with defined experimental protocols and described experimental setups, as well as of all relevant descriptions and tutorials, 2) monitoring of experimental realizations based on available datasets and videoclips, 3) interactive tools for choosing of possible parameters and experimental datasets.

This approach has better accessibility and guide than Internet-mediated laboratories and it is more realistic than virtual laboratories.

## II. Experimental Data Sharing anf Tutoring

Data are the infrastructure of science, research and education. Nowadays, education and research are more data intensive and collaborative than in the past, and there is very important issue concerning data accessibility, re-use, preservation, and especially data sharing. Because of that, publishing of datasets has a great value for sharing experimental results which are a base for further education and research as well as benchmarking analyses [1].

In [7], experimental dataset entitled "I/O data for laboratory model PT326 Feedback Ltd" is published after review process, with accompanying DOI, title, institution, authorship, categories for these data, description of these data, steps to reproduce these data, data files and related links. The purpose of published dataset is reliable and sustainable open educational resource for problem-based learning [1].

Experimental datasets for engineering education purpose can be published on websites, learning management systems (LMSs) like Moodle (https://moodle.com), multi-disciplinary open access archive for the deposit and dissemination of scientific research documents like HAL (https://halshs.archives-ouvertes.fr), personalized learning environments (PLEs) like Graasp (http://graasp.eu), open research data repositories like Mendeley Data (https://data.mendeley.com), Zenodo (https://zenodo.org), Apollo (https://www.repository.cam.ac.uk), 4TU (http://data.4tu.nl), DRYAD (https://datadryad.org), ICPSR (https://www.icpsr.umich.edu/icpsrweb/) and so on [1].

Open science and open education are new paradigms based on open data including experimental datasets.

## III. Dynamic Repository of Experimental Results

Based on open experimental datasets, descriptions of experimental setups and protocols, experimental parameters,

This work has been partly funded by the SCOPES project IZ74Z0_160454/1 "Enabling Web-based Remote Laboratory Community and Infrastructure" of Swiss National Science Foundation and by the project TR33047 of Serbian Ministry of Education, Science and Tech. Dev.

978-1-7281-3636-3/19/$31.00 ©2019 IEEE

repository of characteristic video clips of experimental realization, available guides and tutorials - it is possible to build of dynamic repository of experimental results as a special case of interactive set of demonstrative experiments.

Our intention is to collect and organize all characteristic experimental results from experimental setups (like the depicted one on Fig. 1) including accompanied video clips from experiments. Depending on the chosen set of available experimental parameters relevant set of experimental data are becoming available and can be started for presentation, monitoring, analyzing or downloading of the chosen data.

On this manner different arrangements of presentation and monitoring of experimental results are possible: 1) real-time, faster, slower, 2) one or more experiment with different parameters together, and so on. Saved experimental results are becoming interactive with dynamic presentation like within Internet-mediated experiments. Parallel execution of short experimental phases with saved video clips enables full and effective monitoring whole experimental trial in very short time. This methodology is useful for teaching and discussions with students during lecturing as well as problem-oriented education in general. Pedagogy aspects are included and mapped with teaching aims and learning outcomes.

The four-tank laboratory model for coupled water experiment (Fig.1) is unique in our teaching laboratory and because of potential hazardous effects is not appropriate for experimentation via Internet. Drawback of this laboratory model are also relatively long settling times of this dynamical system. Proposed approach can solve mentioned drawbacks. It will be represented in our example in order to illustrate concepts in modelling, process identification and control. Namely, we promote design and development of experimental learning courses based on dynamic and interactive presentation of repository of experimental results per each from a lot of different experimental plants and laboratory models.

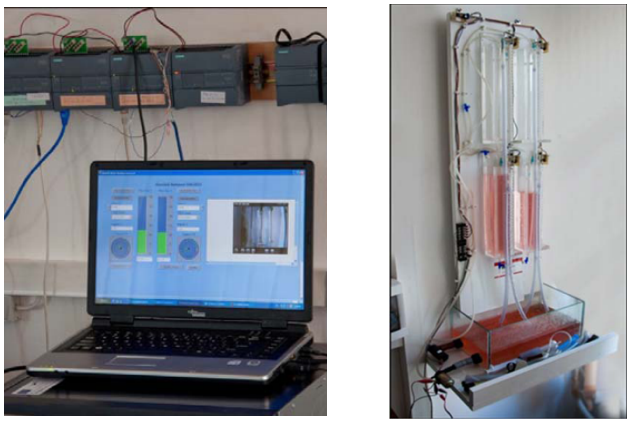

Fig. 1. Coupled water tanks experiments

The web site includes appropriate guides and contents for basic theory, descriptions of experimental setups, and problem based education.

## IV. Conclusion

We would like to promote a new manner of organization and presentation of published experimental data for the purpose of engineering education. At first, in order to better level of responsibility and visibility, datasets should pass review process by publishing as Mendeley Data. Our intention to record all typical and important situations (datasets, video clips) for potential education and research needs. Practically, our goal was to form smart virtual lab which is composed from real datasets and illustrative video clips and diagrams. Graphical user interface enables good level interactivity and choosing of characteristic sets of experimental parameters in order to demonstrate needed theoretical phenomena through saved experimental results and video clips.

From a demonstration point of view this approach is better (because of the high level of credibility, reliability and accessibility to demonstration of an experimental trial) than classical virtual lab or Internet-mediated laboratory. This approach has not potential hazardous effects during experimental exploitation and has minimal maintenance costs. In addition, this approach offers different manners of presentation of experimental results related to chosen time for experiment realization (real time, slower or faster than real time experimental realization) in one experimental session or in divided experimental sessions with parallel presentation.

## References

[1] M. Matijevic, M. Nedeljkovic, Dj. Cantrak, N. Jankovic, "Problem oriented learning based on use of shared experimental results" Proc. of IMCL2018, pp. 251-262, McMaster University, Hamilton, Ontario, Canada, 2018, 11–12 October 2018

[2] E. Graaff, A. Kolmos "History of problem based and project based learning", Management of Change. Sense Publisher. pp. 1–8, 2007.

[3] J.E. Mills, D.F. Treagust, "Engineering education—Is problem-based or project-based learning the answer", Australasian journal of engineering education. 3 (2). pp. 2-16, 2003

[4] M. Matijevic, M. Nedeljkovic, Dj. Cantrak, N. Jovic, "Remote labs and problem oriented engineering education", Proc. of IEEE Global Engineering Education Conference (EDUCON), Athens, Greece. pp. 1390 – 1395, April 25-28, 2017

[5] Gillet D, *et al.* "Monitoring, awareness and reflection in blended technology enhanced learning: a systematic review", International Journal of Technology Enhanced Learning, 9(2/3), p. 126. 2017.

[6] Gillet D, *et al.* "Cloud ecosystem for supporting inquiry learning with online labs: Creation, personalization, and exploitation", Proc. of 4th Experiment at International Conference: Online Experimentation, exp.at *2017*, pp. 208–213, 2017.

[7] M. Matijevic, I/O data for laboratory model PT326 Feedback Ltd, Mendeley Data, v2http://dx.doi.org/10.17632/xw8sg9x8cm.2, 2018.