1st Conference on Research Data Infrastructure
Natural Sciences
https://doi.org/10.52825/CoRDI.v1i.349

Published: 07 Sept. 2023

Integrating Data Literacy into University Curricula

Student Centred Learning in Undergraduate Physics Lab Courses

Janice Bode[1] [https://orcid.org/0000-0003-1777-9148], Philipp Jaeger[2] [https://orcid.org/0000-0002-7526-1489], and Sonja Schneidewind[1] [https://orcid.org/0000-0002-0978-1056]

[1] University of Münster, Germany

[2] Pexon Consulting GmbH, Germany

Abstract: The implementation of competencies regarding Research Data Management (RDM) and Data Literacy (DL) into the curricula is a major challenge for the NFDI community. In physics as well as in other disciples, the beginners' lab courses are the first point in time where students have to deal with data, and are therefore an intuitive point for the integration of first RDM learning objectives. However, the modification of teaching materials is a time-consuming and potentially expensive task. In this contribution the authors show how this can be achieved in the physics beginners' lab on the basis of concrete examples, thereby affecting the education of students in a wide range of subjects, including the sciences, engineering, but potentially also medicine or geology.

Keywords: Data Life Cycle, Data Literacy, Teaching Material, FAIR principles, Higher Education, Lab Courses, Graduate Studies, Physics, Sciences

1 Introduction

There are many views on how to best integrate Research Data Management (RDM) and the Reasearch Data Life Cycle [1] as well as Data Literacy (DL) [2] in curricula across the disciplines. In this work, the authors focus on physics programmes at EQF [3] level 6 (Bachelor's degree) or combined programmes on level 6 and 7 (previous German degrees, e.g. Diplom, Staatsexamen) and programmes that contain a significant share of physics courses, such as biophysics, astronomy, material science etc.

The physics community has been discussing several approaches, including dedicated courses for RDM and DL, or practical learning during the practical phases and thesis projects of the programme. The first option suffers from the already full curriculum which causes difficulties in adding new content. Since students choose individual thesis topics, the second option does not ensure equal RDM content for all students during their studies. Furthermore, at the time of their thesis students may already have adopted some kind of handling data. A third option, which this work focusses upon, is to modify the beginners lab courses in such a way that all students learn and experience the basics of RDM and DL while taking the courses, and thereby also become familiar with the FAIR principles [4]. The key arguments in favour of such an approach are [5]:

- During the beginners lab, students work with “real” experimental data for the first time, making it a natural starting point to teach RDM.
- By sharing data during the lab, it is possible to analyse data in a more complex fashion, and hence to answer more interesting and relevant questions.
- The implementation of the necessary changes is quite straightforward. In particular, no changes to any examination regulations become necessary.
- The anticipated outcome can be achieved mostly by changing the way experiments are conducted by the students and without additional personnel requirements.

2 Exemplary Experiments

While the first three steps of the Research Data Life Cycle – creating, processing and analysing data – are naturally already included in most of the lab classes, the last three steps – preserving, giving access to and re-using data – are currently missing in most cases. In the following, two exemplary experiments in which a simple modification can enhance the learning outcome regarding DL are described:

2.1 Radioactive decay

An exemplary implementation of all life cycle steps is possible in experiments using radioactive sources, which exist at most universities. Sources like ^{252}Cf with a half-life time of $2.6\,$a [6] allow the modelling of radioactive decay without additional efforts by applying the different data life cycle steps: Different lab groups perform their experiment in which along the way raw total counts measured from the source are obtained (*creation of data*). The *processing* and *analysis* of this data easily leads to a total count rate. If this rate is collected in digital form from each group (*preserving data*), e.g. in form of a pandas dictionary, following groups can *get access* to this growing data set, and *re-use* it to probe the law of radioactive decay.

2.2 Specific heat of metals

As a second example, in a thermodynamics experiment for the measurement of the temperature dependence of specific heat $c(T)$ of metals, different groups can determine $c(T)$ for one material each (Al, Cu, Pb...) and thereby once experience the whole measurement process on their own. They can then exchange their data (*giving access*) and each analyse the data sets of all groups. By doing so, students on the one hand learn how to record data such that others who did not do the experiment by themselves are able to analyse it, and on the other hand naturally learn how to profit from data which is already taken by others.

The implementation of new topics in existing courses certainly needs to be monitored by appropriate evaluation methods, following the PDCA cycle [7] (plan, do, check, act). It is well-established to offer this task as theses e.g. for graduate or PhD students in education. Continuous evaluation of the lab course allows for immediate reaction to any problem which might arise over time, and is expected to improve the experiment itself, leading to improved student success and a higher rate of students achieving the desired learning outcomes [8]. Additionally, it becomes easier for the teaching staff to adapt to improved technology and methodology in the field.

3 Conclusion

The authors would like to emphasise the strength of the given approach, which is to achieve high impact with only small modifications of existing lab experiments. While the examples given in this contribution are specifically for physics programmes, the underlying idea can be easily adopted by other disciplines: In every programme where students work empirically with data, the corresponding courses can be used as a starting point for teaching RDM and DL competencies by introducing comparably small changes to the curriculum.

To summarise, this contribution specifically outlines how it can succeed to modify common beginners lab experiments in order to add DL competencies to the learning outcomes of the students. Based on the Research Data Life Cycle the authors suggest experiments and outline correspondence to the six stages thereof. For each case, the desired learning outcomes are discussed in detail.

Author contributions

The authors declare that they contributed equally to the present publication throughout all stages of the project. The authors are listed in alphabetical order.

Conflict of interest/Competing interests

The authors declare that the have no competing interests.

Funding

This work has no funding.

Acknowledgements

The authors acknowledge fruitful discussions and collaboration with junge Deutsche Physikalische Gesellschaft (jDPG) and Zusammenkunft aller deutschsprachigen Physikfachschaften (ZaPF).

References

[1] A. M. Tammaro and V. Casarosa, "Research data management in the curriculum: An interdisciplinary approach," *Procedia Computer Science*, vol. 38, pp. 138–142, 2014, 10th Italian Research Conference on Digital Libraries, IRCDL 2014, ISSN: 1877-0509. DOI: https://doi.org/10.1016/j.procs.2014.10.023.

[2] R. Schneider, "Research data literacy," in *Worldwide Commonalities and Challenges in Information Literacy Research and Practice*, S. Kurbanoğlu, E. Grassian, D. Mizrachi, R. Catts, and S. Špiranec, Eds., Cham: Springer International Publishing, 2013, pp. 134–140, ISBN: 978-3-319-03919-0.

[3] European Parliament Council, "Recommendation of the european parliament and of the council of 23 april 2008 on the establishment of the european qualifications framework for lifelong learning," *Official Journal of the European Union*, vol. 51 C 111, pp. 1–7, 2008.

[4] I. A. e. a. M. Wilkinson M. Dumontier, ""the fair guiding principles for scientific data management and stewardship"," *Sci Data*, vol. 3, 160018, 2016. DOI: https://doi.org/10.1038/sdata.2016.18.

[5] J. Bode and P. Jaeger, "Chapter 5 - Redet über die Daten! - Forschungsdatenmanagement und Hochschullehre in der Physik und darüber hinaus," in A. Aljanazrah, S. Brackertz, J. Gehlert, *et al.*, Eds., vol. 1, Oct. 2021, pp. 512–516. DOI: https://zenodo.org/record/5168524. [Online]. Available: https://ojs.dpg-physik.de/index.php/phydid-b/article/view/1180.

[6] G. R. CHOPPIN, J.-O. LILJENZIN, and J. RYDBERG, "Chapter 16 - the transuranium elements," in *Radiochemistry and Nuclear Chemistry (Third Edition)*, G. R. CHOPPIN, J.-O. LILJENZIN, and J. RYDBERG, Eds., Third Edition, Woburn: Butterworth-Heinemann, 2002, pp. 415–439, ISBN: 978-0-7506-7463-8. DOI: https://doi.org/10.1016/B978-075067463-8/50016-9. [Online]. Available: https://www.sciencedirect.com/science/article/pii/B9780750674638500169.

[7] "Deming cycle (pdca)deming cycle plan-do-check act (pdca)(pdca)," in *Encyclopedia of Production and Manufacturing Management*, P. M. Swamidass, Ed. Boston, MA: Springer US, 2000, pp. 155–155, ISBN: 978-1-4020-0612-8. DOI: 10.1007/1-4020-0612-8_229. [Online]. Available: https://doi.org/10.1007/1-4020-0612-8_229.

[8] Ministerial Conference of the European Higher Education Area (EHEA), "Paris communiqué," 2018. [Online]. Available: https://ehea.info/Upload/document/ministerial_declarations/EHEAParis2018_Communique_final_952771.pdf.