PER-Based Curricula for Middle and High Schools

Martin HOPF (1), Thomas WILHELM (2), Horst SCHECKER (3)

(1) Universität Wien, Didaktik der Physik, 1090 Vienna, Porzellangasse 4, Austria
(2) Goethe-Universität Frankfurt, Institut für Didaktik der Physik, 60438 Frankfurt am Main, Max-von-Laue-Str. 1, Germany
(3) Universität Bremen, Institut für Didaktik der Naturwissenschaften, Abt. Physikdidaktik, 28334 Bremen, Otto-Hahn-Allee 1, Germany

Abstract: Curricula contain detailed information on how to teach (physics) topics. It is amazing and surprising, how differently curricula for the middle and high school physics classroom can be designed, how the sub-topics can be arranged and which explanations and visualisations can be used. On the poster, we give a brief introduction to curriculum development and its history as well as short examples from German language PER-based curricula.

Curricula for the physics classroom

Why does physics in upper secondary school almost always start with kinematics and dynamics? And why does electricity almost always start with current (instead of potential and voltage)? If you think a little about these questions, it quickly becomes clear that there are no really compelling arguments. The assumption that the order of physics topics is necessarily logical and that basic physics concepts must be introduced in a certain way – e.g., the way one experienced it oneself in class as a pupil – proves to be wrong. Depending on the age and the learning prerequisites of the students, very careful consideration must be given to which aspects can be dealt with, how they can be explained in a comprehensible way and how they can build on each other. And of course, this has often been done in PER and a lot of excellent curricula were developed. In many cases the effects of such curricula have been carefully evaluated. And it turns out, that many – sometimes very different – curricula exist to teach the same physics concept. To be sure, with curriculum we mean an explicit teaching programme or a draft developed on the basis of guiding ideas for the teaching of a physics topic, not a national curriculum.

Most curricula we know are based on certain central ideas, e.g. using the electron gas as an analogy for teaching the simple electric circuit [1]. The concepts of manyexisting curricula are elaborated in textbooks. Additionally, teaching materials, suggestions of suitable experiments and background information are available for teachers. Sometimes such materials are even available for free on the internet.

Origins of Curricula

Textbooks are one important source of curricula. A curriculum is often continually refined by its developers over the years until it is finally taken up by textbooks. In the 1980s, for example, Feynman's phasors found their way into textbooks for the upper secondary level [2].

Another source were the major curriculum projects from the second half of the last century. Large development teams with members from physics, education authorities and schools designed new types of courses [e.g. 3].

More recently, the main contributions to the development of curricula come from PER. Researchers at many institutes are working on identifying new ways of teaching physics. The empirical question of learning effectiveness plays a central role: which learning offers are well received by students and prove to be adaptable for future learning, and which other learning offers do not work. For research and development of PER-based middle and high school curricula the model of Educational Reconstruction [4] plays a significant role.

Examples of Curricula on Electricity

The physics of the simple electric circuit is very abstract and much more difficult for students than often expected by teachers. Thus, there are large number of different curricula for this topic. We know of at least six quite different approaches from German-speaking countries [5]. All of these curricula are quite different from each other. For choosing a certain approach, one has to decide which quantity is the most important. The electron gas curriculum [1] is based on the voltage and works with a pressure analogy. Other curricula focus on the electric current as the main concept of simple circuits. Still others focus on the transport of electric energy [5].

Outlook

Over the last years, we have evaluated the German language physics curricula for middle and high school level. In a newly published textbook "Unterrichtskonzeptionen für den Physikunterricht" [6] we provide overviews of curricula for the different physics topics. We discuss the curricula so that physics teacher can decide on their preferences. On a website [7], we put together freely available teaching materials for classroom use.

Even so, we will have missed many important curricula. We would like to invite our colleagues to cooperate with us on collecting further PER-based curricula for the physics classroom.

References

[1] J.-P. Burde and T. Wilhelm. Teaching electric circuits with a focus on potential differences. *Physical Review Physics Education Research* **16** (2020).

[2] F. Bader and F. Dorn, F. (Hrsg.). *Dorn/Bader. Physik-Oberstufe. Gesamtband 12/13.* Hannover, Schroedel (1986).

[3] U. Haber-Schaim. *PSSC Physics: A personal perspective*. American Association of Physics Teachers (2006). https://www.aapt.org/Publications/upload/Haber-Schaim4068.pdf

[4] R. Duit, H. Gropengiesser, U. Kattmann, M. Komorek and I. Parchmann. The Model of Educational Reconstruction – a framework for improving teaching and learning science. 10.13140/2.1.2848.6720. (2012)

[5] J.-P. Burde and Th. Wilhelm. Unterrichtskonzeptionen zu elektrischen Stromkreisen. In

[6] T. Wilhelm, H. Schecker and M. Hopf (Hrsg.). Unterrichtskonzeptionen für den Physikunterricht. Springer Spektrum (2021). T. Wilhelm, H. Schecker and M. Hopf M. (Hrsg.). *Unterrichtskonzeptionen für den Physikunterricht.* Springer Spektrum (2021). https://doi.org/10.1007/978-3-662-63053-2

[7] https://aeccp.univie.ac.at/lehrer-innen/unterrichtskonzeptionen/