

Changing aims in compulsory physics education – from qualifications towards competencies

Jens Dolin

University of Southern Denmark

jens.dolin@dig.sdu.dk

Abstract

The adaptation of physics education to a changing society appears as a conflict between different overall aims. Three aims – qualifications, general education (“bildung”), and competencies – are being discussed. Based on the results of an action research project in upper secondary physics in Denmark, a description of what may be meant by being competent and being “educated” in physics is presented. Some of the consequences of implementing a competency-based education will be indicated, both regarding classroom practice and assessment.

Introduction

During the last 5-10 years the general educational aims - as well as the goals for the individual school subjects such as physics - have changed. There are several parallel reasons for these attempts to reformulate the justifications for having physics. A rapidly changing society makes even consolidated knowledge such as physics, at least in its traditional form, inadequate for most professional use. In trade and industry emphasis is to a large degree on personal and social competencies – creativity, problem solving, collaboration, etc. – and the professional skills are more or less taken for granted or expected to be learned within a short period. This means that the school subject must focus more on general procedures, giving the students an idea of the fundamental principles within the field, and on the ability to learn. At the same time there is a growing mutual dependency between science and society. To be able to understand many current societal problems and to engage in democratic processes you must have some scientific knowledge, but having the complexity of modern science in mind you rather need to have some knowledge *about* science. The metaperspectives and the history and philosophy of science are just as important as the concrete knowledge. Large, national curriculum projects such as *Beyond 2000* [1] and *Project 2061, Science for All Americans* [2] follow these ideas. The OECD Programme for International Student Assessment (PISA) [3] focuses on testing the students’ scientific literacy as a measure of “... the knowledge and skills that are essential for full participation in society.”

Finally a frightening amount of research tells us that traditionally taught physics fosters poorly motivated students. It also points out how difficult it is to learn physics and to what low degree physics learned in the classroom can be transferred to other situations [4][5]. These insights from learning theory have forced teachers and curriculum developers to set up more modest goals and to change both the content (more everyday and societal problems) and the instruction (more project orientation and authenticity)[1][6].

The trends mentioned here are reflected in the struggle between various overall aims for the educational system in general and physics in particular.

The traditional aims

The Danish educational system has traditionally operated with two complementary aims: Qualifications and “Bildung”.

Qualification reflects the well-known core curriculum. It labels your knowledge within the field; to what degree you know the definitions and can solve the equations.

Bildung is a more complicated concept used in Germany and The Nordic countries and it has some connotations in common with cultural or liberal education. The German word is derived from to form or to shape, stressing how education should contribute to the students’ identity building at the same time as it gives the students the necessary qualifications (for instance for further education). It can be argued that *bildung* in physics comprises:

knowledge (the aspect of content)

critical reflections on knowledge (the aspect of perspective)

the establishment of personal attitudes towards knowledge (the aspect of identity).

None of these three dimensions is sufficient on its own.

The two concepts reflect two different traditions in relation to teaching and learning: The (American/Anglo-Saxon) curriculum tradition and the (German) didaktik/bildung tradition [7].

It is important to notice that although both aims are equally weighted in the preamble for upper secondary education, everyday practice mainly deals with qualifications. This simply reflects that the examinations

test your concrete knowledge and your ability to use them in well known, subject specific contexts.

Competencies as a new mantra

During the last 5-10 years competencies has intruded into the educational system (in Denmark at least) as a way of describing the desired outcome of education. The influence has come mainly from the business world, but also from OECD's DeSeCo project [8]. Competencies are seen as the capability of mastering complex (working) situations. It is knowledge in action in relevant situations. So focus is on action, on the applicability of the knowledge, maybe at the expense of having a broad, comprehensive view of the whole subject.

Competencies in physics

The results reported here comes from a collaborative action research project in the Danish upper secondary school (gymnasium). I followed three classes in the two years compulsory physics (year 10-11). The teachers and I worked together on developing an instruction that emphasized the acting aspects of physics, i.e. the students' ability to solve physics-rich everyday problems. We discussed what were the characteristic forms of knowing and doing in physics and how to put them into practice in the classroom. And at the same time we wanted to enhance the bildung aspects in a more binding way by formulating them in competencies terms. I monitored the implementation and the students' motivation and attitudes towards physics.

Out of this project and subsequent work, the following conceptualisation emerged:

As the fundamental physics competencies the students should be able to

- build and analyse models,
- plan, perform and describe experimental work,
- work with different representations of the same phenomenon,
- put physics into cross curricular, historical, philosophical, and personal perspectives.

The fourth bullet represents the bildung aspect.

The competencies were developed in more details, but the underlying principle is that these competencies are content invariant. They can be obtained by working with any physics content.

Teaching for competencies in physics

To teach for competencies you have to reverse your way of thinking, putting the outcome first.

You could speak of a *leap of competency*, where in stead of asking:

What must the pupils *know* – and what must they *do* to achieve this? you ask:

What must the pupils be able to *do* – and what must they *know* so that they can?

Doing this, practice showed an educational setting characterized by

- Guided discovery
- High degree of student participation
- Groupwork, problemorientated
- Open ended questions (uncertainty and diversity)
- Dialogue/argumentation
- Complex assessment assignments, groupbased project examination

The education was *explorative* and *community* organised.

Conclusions

The project established a framework for a competency orientated physics education and gave some guidelines for its implementation. All students in three classes proved able to learn the fundamental physics competencies, and after two years of this physics education, the students expressed an attitude towards physics dramatically different from other students at the same level:

- the students did not consider physics more difficult than other subjects
- physics became significantly more relevant, greater interest in science in general, stronger engagement etc.
- specially the girls became more interested etc.
- the students considered physics as epistemologically valuable rather than a concrete content.

References

- [1] MILLAR, R. and OSBORNE, J. *Beyond 2000: Science education for the future*. London, King's College London, 1998.
- [2] www.project2061.org
- [3] OECD. *Measuring Student Knowledge and Skills - a New Framework for Assessment*. OECD, 1999.
- [4] DUIT, R. and TREAGUST, D.F. Learning in Science – From Behaviourism Towards Social Constructivism and Beyond. In FRASER, B.J. and TOBIN, K.G. (eds.) *International Handbook of Science Education*. Kluwer Academic Publishers, 1998.
- [5] BROWN, J. S., COLLINS A., et al. Situated Cognition and the Culture of Learning. *Educational Researcher*, 1989, 18(1): 32-42.
- [6] DOLIN, J. *Authenticity as a guideline for a competence oriented science education*. Paper presented at the 4th ESERA Conference, 2003.
- [7] WESTBURY, I., HOPMANN, S., and RIQUARTS, K. (eds.). *Teaching as Reflective Practice: The German Didaktik Tradition*. New Jersey, Lawrence Erlbaum, 2000.
- [8] RYCHEN, D. S. and SALGANIK, L. H. (Eds.). *Defining and selecting key competencies*. Hogrefe & Huber Publishers, 2001.