

milq (Munich Internet Project for Learning Quantum Mechanics)

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milq (Munich Internet Project for Learning Quantum Mechanics) is an in-service-teacher training which uses the Internet as a medium to guide and support a learning process about the basic ideas of quantum mechanics. An essential part of this course is the information about actual topics of physical research. “milq” also offers teaching materials and hints for teaching quantum mechanics at school. In this article the structure and the contents of “milq” will be presented and the first trends in the evaluation results of this kind of in-service-teacher-training will be indicated.

“milq” [1] is an example of a new method of teacher advanced training: via the Internet it is possible to take part in a in-service-teacher training, which contents can be comfortably worked on at home, at any time and by a not restricted number of participants. Therefore potential long and expensive journeys to the venue and restrictions by the limited number of participants do not arise. Further advantages are that multi-media based elements like applets, simulation programs, Interactive Screen Experiments (ISE) and small video films can be integrated immediately, because they are available at any time for use in school besides other teaching materials.

A discussion about quantum mechanics at school is unavoidable, because in the meantime quantum physics is a steady and important component in the teaching and learning curricula. This, however, is more difficult than the discussion on other branches of physics: the underlying theory is very mathematical and abstract and, hence, there are partially not enough clear representations and explanations. Within the scope of studies at university a very formalistic knowledge at a mathematical high level is acquired, which serves merely as background knowledge for the implementation at school. Furthermore quantum physics is still an object of actual research and cannot be considered as a closed branch of physics. More and more experiments in this context are opening new application possibilities as for example the quantum teleportation, the quantum computer and – combined with this – also the quantum cryptography.

These points are good reasons for a well-founded discussion about quantum physics in schools. The Munich draft [1], [2] has been originated on the basis of earlier papers (e.g. [3]) on learning difficulties, the problems of interpretation and its critical analysis of teaching processing in the field of quantum mechanics. In this draft the conceptual understanding of quantum mechanics is particularly ostensible. For this reason two main focuses are especially important:

- quantum mechanics is fundamental different from classical physics and
- the accentuation on the interpretation questions of the quantum mechanics.

Since there is a general need for detailed background knowledge and processed materials concerning the standard subjects as well as for the ranges of application of quantum physics at school, the Munich draft is offered besides additional working materials and further information in form of an Internet-based in-service-teacher training.

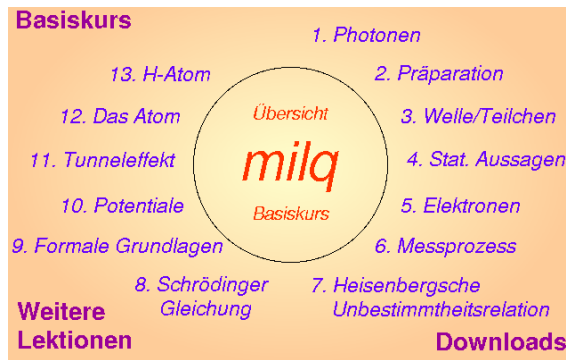


Fig. 1. Survey of milq

The offered thirteen sections are divided into a qualitative basic part (sections 1 – 7), within the conceptual understanding of quantum physics is ostensible and a quantitative advanced unit (sections 8 – 13), within the mathematical formalism of the quantum mechanics is introduced on a simple mathematical basis. The single sections consist of a teaching text, which is available as a PDF-document for printing, the on-line sides, which are formed in support of the teaching text and integrated applets and simulation programs as well as additional materials ([U](#)- and [I](#)-links). The [U](#)-links are containing teaching materials and hints for teaching quantum physics at school and the [I](#)-links are providing background information and mathematical derivations on the single subjects of the sections. Since the contents on the single on-line sides remain clearly structured, the additional information is offered on linked sides. This leads to receive the small, manageable sections and reduces the “lost in hyperspace”-phenomenon. A possible excessive demand is thereby avoided and also extensive learning modules.

The offered simulation programs (e.g. double-slit experiment, polarization filter, Mach-Zehnder interferometer) can be used immediately in school and allow an independent activity with quantum phenomena. Just because the experiments in connection with quantum physics are partially not practicable for school (on the one hand the equipment at some schools is not sufficient and on the other hand the experiments can only be performed in great labs with adequate equipment), the computer simulations can support the learning process.

Besides the contents of the Munich teaching draft representations on subjects of the actual physical research and further didactical information are offered.

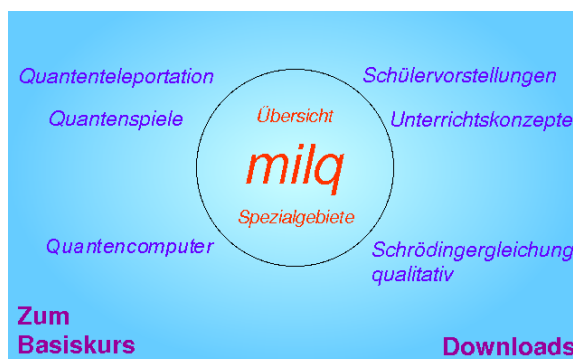


Fig. 2. Survey of additional subjects

It is planned to complement the special subjects in “milq” with topics for example quantum cryptography and superconductivity.

To receive a certification about the participation in the in-service-teacher training “milq”, a questionnaire at the end of the sections shown in figure 1 has to be filled in and sent back. The average time needed to edit a single section is between 30 minutes and one hour; this means that this kind of training is comparable to a two-day teacher advanced training.

For this – as far as we know – new way of teacher training in physics questionnaires and interviews are at the moment used to evaluate the project. In particular the advantages concerning the free choice of time and place are the main reasons for the excellent acceptance of this kind of teacher training which is shown in the first results of the evaluation. Nevertheless, traditional training courses should be integrated in this Internet-based teacher advanced training about technical and special didactical contents, because in the new training the participants work isolated: important social components are getting lost. Communication and exchange – particularly about implementation in school – about the offered discussion forum does not take place, because such a type of communication is felt to be too impersonal.

[1] <http://www.cip.physik.uni-muenchen.de/~milq>

[2] Müller, R., Wiesner, H. (2002): Teaching quantum mechanics on an introductory level, AJP 70, 200-209

[3] Wiesner, H. (1988): Beiträge zur Didaktik des Unterrichts über Quantenphysik in der Oberstufe.

Westarp Verlag, Essen