Report on Available Multimedia Material for a Lecture in Quantum Mechanics

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Introduction

Since a few thousand applets to teach physics are nowadays available worldwide, since about ten media server to collect material are now functioning, since a few textbooks for universities already include multimedia material (MM), since individual websites of universities physics professors contain excellent MM for teaching and learning ... it is now time to start a systematic analysis on that matter: to collect what is available, to evaluate this material according to criteria, to recommend and disseminate good material.

One cannot expect from an ordinary professor in physics, mainly involved in research and administration, to perform such an analysis by himself, when he has taken the duty to teach a lecture on topic x.

These two facts were the reason why we started for the first time during this workshop in Parma to deal half a day with multimedia material for a lecture in quantum mechanics. We will have invited talks, where speakers can describe their own material, we will have reports, what is available, and at the end a group must take the responsibility, to suggest what is a „good" material and why it is good.

To start with – but this procedure should be discussed or changed, if it does not work – a working group WG5 within EUPEN [http://inwfnu07.rug.ac.be/eupen/] was founded in spring 2002 to act as a referee group and define a set of evaluation criteria. Members of this group have long years of experience in giving lectures in experimental or theoretical physics. This group participates on that workshop in Parma and will publish their results in the proceedings (Recommendations by M. Benedict et al).

It is planned at the next workshop in Prague 2003 to choose another lecture (e.g. electrodynamics, optics, solid state physics) and to discuss critically the procedure and criteria of the evaluation process, established here for the first time.

Collection of material

A Gordon conference on Physics Research and Education was held in June 2002 on quantum mechanics (http://www.grc.uri.edu/programs/2002/phyres.htm) and M. Belloni, who attended this conference, will comment on that in his second speech in Parma. The journal American Journal of Physics published a thematic issue on quantum mechanics (Am.J.Phys. **70,3**, 2002) and Phys. Education focussed with an issue how to use internet for physics teaching (Phys. Educ. **37** (2002)).

In the following some links related to textbooks or teacher training courses:

- book by Springer + CD: Visual Quantum Mechanics
  http://www.kfunigraz.ac.at/imawww/thaller/index.html
- teacher training course on QM
  http://www.physik.uni-muenchen.de/didaktik/milq/index.html
- plenary talk in Parma by Mario Belloni
  http://webphysics.davidson.edu/physlet_resources/quantum.html
  http://webphysics.davidson.edu/mjb/ncs_aapt_qm_2002/welcome.html

- quantum mechanical models of solids (lecture)
  http://www.hpc.susx.ac.uk/~venables/timetab00.html
- lecture notes, online courses, tutorials, textbooks, visualization/demonstrations (applets), related collections (~30)
  http://physnet.uni-oldenburg.de/PhysNet/quantum.html

The next list is just a collection of individual products, which we found during our search worldwide during the last year:

- http://www.schulphysik.de/java/physlet/applets/quant1.html
- http://www.schulphysik.de/java/physlet/applets/quant2.html
- http://www.sc.ehu.es/sbweb/fisica/cuanzica/fisicamoderna.htm
- http://www.astro.uni-bonn.de/~deboer/pdm/pdmelmag.html
- http://www.physik.uni-regensburg.de/forschung/zweck/vorlesungen/pia1(1-110).pdf
- http://www.physik.uni-regensburg.de/forschung/zweck/vorlesungen/pia1(111-222).pdf
- http://www.phyun0.ucr.edu/vandalen/phy40e/40e_lect.html
- http://www.itkp.uni-bonn.de/~metsch/pdm/pdmquant.html
- http://www.psc.edu/~wimberly/html/quantums.html
- http://www.library.thinkquest.org/c005775/intro.html
- http://www.phys.educ.ksu.edu/index.html
- http://www.electron6.phys.utk.edu/qm1/
- http://www.electron6.phys.utk.edu/qm2/
- http://www.newton.phy.bme.hu/education/schrd/index.html
- http://www3.adnc.com/~topquark/quantum/quantumapplets.html
- http://wwwvis.informatik.uni-stuttgart.de/~kraus/livegrafics3d/java_script/sphericalharmonics.html
- http://www.quantum-physics.polytechnique.fr/
- http://www-chem.unifr.ch/pc/dir_allan/superwave.html
- http://www.Colorado.edu/physics/2000/index.pl
- http://www-ekp.physik.uni-karlsruhe.de/~feindt

At the end some useful links (not QM) which are – due to me – of certain relevance:

- refereed collection of multimedia
  http://www.merlot.org/artifact/BrowseArtifacts.po?catcode=12&browsecat=0
- partially! refereed collection
  http://www.renardus.org/cgi-bin/egwcgi/5825/screen.tol/name=Start&lang=eng&service=neu
  http://newton.physics.wwu.edu:8082/jstewart/scied/physics.html
  http://www.utexas.edu/world/lecture/

- individual products
  Physics house (physics in everyday life)
  http://www.iop.org

My personal résumé

About 40% of the material did not work (website not found, server disabled etc.), which means it is not sufficient to produce once good material, this material on a server must be maintained and updated.

The about 25 links on QM offer mostly (80%) standard topics, i.e. orbitals of H-atom, wave package, eigenwert problem, harmonic oscillator.

To characterize websites one should have a logic order and not like in medieval times, when people named their streets: www.department x/lecture y/author z/

The material I found is either like traditional textbooks now in electronic version with photos, dictionary, or a glossar ... or simulations/animations with some small texts.

According to me multimedia is not really integrated in textbooks: e.g. if there is a graph or a picture of an experiment (photo effect) I would expect to open a video of the real experiment or an animation for explanation.

Up to now the existing material is not exploiting the full power of multimedia.

By some selected examples I would like to demonstrate that there is already existing excellent material:

- http://www.schulphysik.de/java/physlet/applets/quant1.html
  This material was prepared by W. Christian (Davidson College, USA) for German physics teachers. See also the websites in combination with the plenary talk by M. Belloni (member of W. Christians group). This whole material covers many subjects and phenomena of a lecture in QM. This course by W. Christian is between what we teach at our schools (pupils in the age of 18 years) and an introductory course in QM.
- http://www3.adnc.com/~topquark/quantum/quantumapplets.html
  This material contains 6 examples, what I named before standard topics (H-atom, scattering of square walls etc.). But besides the program, the authors offer excellent necessary material about the physics (about one page) and instructions, how to use the material.
- http://www.quantum-physics.polytechnique.fr
  This material (in english or french language) contains 7 chapters like introduction/motivation, wave mechanics, quanisation in 1D, superposition of quantum states in 1D, in 2D and in 3D, spin ½. Each chapter possess about 5-7 subchapters describing new examples like wave particle, wave package, scanning tunnelling microscopes etc. This material uses animations, interactive simulations, short texts and dictionary of names etc. By that technic complex phenomena are visualized.
- http://www.Colorado.edu/physics/2000/index.pl
  Personally I do not like this material: it is a „dialogue“ between two persons, level basic courses for secondary schools (age 17-18 years); I cannot imagine that our teachers would teach by that product. But on the other side it contains a huge amount of MM material for modern physics: Einstein legacy, atomic lab, science trek. Due to me the enormous advantage of this material is that the authors tried to present complex phenomena in a simple form (over-simplifications, didactical reduction): the reader may convince himself and look at the part on BEC (Bose-Einstein Condensation).

Criteria for evaluation

To my understanding if I judge a MM material to be „good“ material, means to apply a reasonable set of criteria to this material. Since about 1975-80 the physics community was producing teachware, i.e. to use PC to improve teaching and learning (simulation, animation programs, computerized experiments etc.). During these decades many collections of criteria or descriptions of evaluation processes were published. Part of it is applicable here.

I suggest a pragmatic approach (modus vivendi): i) more than 10 or less than 5 criteria are not appropriate or feasable; ii) from a large list of criteria (see later) someone should choose about 10 criteria, as a first step; iii), we should apply this evaluation procedure for a few years and should modify this list of criteria if necessary.

Following a list of different sets of criteria found in literature:

- MERLOT
  (The **M**ultimedia **E**ducational **R**esource for **L**earning and **O**nline **T**eaching, http://www.merlot.org/)
  Evaluation Standards for MERLOT/Physics
  (http://taste.merlot.org/disciplines/eval_criteria/physicscriteria.html)

1. Quality of Content
2. Effectiveness as a Teaching-Learning Tool
3. Ease of Use

from the about 40 detailed criteria some examples only:
- Is the textual material accurate and precise?
- Is the material modular so that it can be adapted to different physics problems?
- Does the material promote active student engagement?
- Does the material load and run on (a) standard computer system(s) in a manner transparent to experienced users?

- European Academic Software Award
  (http://www.easa-award.net)

  Judging criteria
  - General criteria
  Formal
  Submissions can
  - consist of academic, student-led or, higher education or research based, commercial projects
  - use any generally accepted operating system (preferably Windows, MacOS, OS/2 or Unix) and be designed for workstations or personal computers
  - use documented and, if not standard, included supportive software (e.g. uncommon multimedia players, database engines, etc.)
  Internal
  Submissions should
  - demonstrate innovative use of ICT within higher education and research
  - include either new software or novel use of existing ICT facilities
  - be based on work that is conducted within a European country
  - if submitted from research projects, have some general relevance outside narrow, specific areas of research (through e.g. serving as an example in teaching, being applicable in broader research area, etc.)
  Additional
  - Making use of EC-funding, e.g. the Fourth Framework Programme, might be beneficial for the submissions.
  - The commercial status of all submissions must be clear to the jurors.
  - Evaluation criteria
  Pedagogy and Research
  Submissions should demonstrate:

- appropriate use of ICT to benefit learning/research
- a sound educational/scientific approach taking into account the varied needs of users
- evidence of impact on educational/scientific practice (i.e. tested in real-life settings)
Design
Submissions should be
- well-designed and user-friendly with easy-to-use interface and documentation
- imaginative and up-to-date in their use of technology
Portability
Submissions should be appropriate for use in different countries. (e.g. different languages, different educational traditions, etc.)
Language criteria
- Administrative materials, including forms and instructions for contestants and jurors, will be provided in English.
- Submissions should preferably use English, but any of the EKMA partner languages will be accepted. It should be noted that EKMA can not guarantee assessment of submissions in every language.
- Submission forms should be entered in English, but any of the EKMA partner languages will be accepted.
- The language of the EASA 2002 finals is English. All presentations, demonstration versions and sample materials should be in English – although, regarding the criteria of portability, demonstration versions could use any other EKMA member language

- Medida-Prix
  (http://www.medidaprix.org)

- product oriented	didactical approach
	motivation
	curriculum
	usability
	design
- process oriented	integration
	transportability
	lasting, permanent
	quality assurance
	dissemination
- content	degrees
	broadness
	correctness

- Ross, S. M. and Morrison, G.B.
  (Evaluating interactive media: Issues and suggested practices. In Schenkel, P. (editor): Qualität und Evaluation von Lernsoftware. Nürnberg (Germany) BW Verlag für Bildung und Wissen. In Press).

– needs analysis	
– methodology	program analysis
	participant analysis
	evaluation design
	instrumentation
	implementation

– data analysis and interpretation
– disseminating results

- from discussions with interested people:
  – download time
  – validity of hyperlinks
  – possibility to customize content
  – multimedia material must be interactive, animated, collaborative, relevant, motivating, differentiated
  – classifying criteria into content
    application to teaching
    technical aspects

Finally it is planned that the working group WG 5 of EUPEN will try to select and to justify such a manageable list of criteria (see article: Recommendations by M. Benedict et al).

Conclusion

The expected result of my report should be twofold: i) from my list of links of multimedia material for a lecture in QM a short list of „good“ material should be recommended to the community; ii) from the collection of criteria a short manageable, feasible list of criteria should be also recommended for application in evaluation procedures.

We need for the use of multimedia in physics teaching and learning a refereed database like Merlot in the USA. It would be more than wise and economic to have one only on European level, maybe managed and organized by the EPS. But to begin with and not to wait for another year, I suggest to rely on the members of working group WG 5 within EUPEN as a first approach (see article: Recommendations by M. Benedict et al).