A new multimedia resource for teaching quantum mechanics concepts

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Overview of the animations

- Aimed at University students and instructors
- Created in Adobe Flash, Mathematica used for calculations and graphs \(\rightarrow\) small file size, inexpensive to produce
- Based on outcomes of education research and our lecturing experience (four quantum mechanics lecturers involved)
- Evaluation (questionnaires, diagnostic surveys, observation sessions) used to optimize the animations.
- Complementary to other multimedia resources (PhET, Physlets, QuILTs, etc.)
- Freely available at \textcolor{blue}{www.st-andrews.ac.uk/~qmanim}

see also Kohnle et al., Eur J Phys, 31, 1441 (2010)

Key features of the animations

- Interactivity
- Emphasis on time-dependent behaviour
- Adaptability to a variety of learning goals
- Instructor worksheets with full solutions

Animation topics

- >40 animations developed to date
- Probabilistic/interpretation of classical systems (2)
- Bohr’s model of the hydrogen atom (1)
- Photoelectric effect (1)
- Probability current (1)
- Wave packets (5)
- The Heisenberg Uncertainty Principle (2)
- Momentum probability densities (3)
- The one-dimensional infinite square well (10)
- The finite well (2)
- The harmonic oscillator (5)
- Bound states in other one-dimensional potentials (5)
- Measurement and wave function collapse (1)
- One-dimensional scattering (4)
- Expansion in eigenstates (5)
- The sudden approximation (3)
- Bound states in two-dimensional potentials (3)
- Time-independent perturbation theory (4)
- Multi-particle wave functions (2)
- Spin and angular momentum (5)
- Density matrix (1)
- Quantum information (1)
Student observation sessions

- Individual sessions with five student volunteers from Edinburgh and eight from St Andrews.
  - Students asked to “think aloud” while interacting freely with a previously unseen animation.
  - Questions aimed to test whether graphs and explanations make sense.
  - Follow-up interview on experience with this and previous animations.
- Consistency in issues raised. Outcomes used to optimize interface design and content of all animations.

Diagnostic survey outcomes

- Diagnostic survey given to level two Quantum Physics class at a time when only half of the class had used two animations in a workshop.
- Students that had used the animations outperformed students that had not on those questions pertaining to the animation topics.
Conclusions

- Number of animations has been doubled in the past year, extending the range and topics of animations available.
- Observation sessions used to optimize interface design and content.
- Evaluation shows positive short-term learning gains.

Future work

- More detailed investigation of student use and long-term learning gains
- Extend number of animations and instructor resources available, e.g. quantum information theory
- More external user input
- Integrate animations into multimedia learning modules

Animations available (use and download) at www.st-andrews.ac.uk/~qmanim