



Teaching Calculus-Based Quantum Mechanics in a General Education Course

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My Goal

- Present foundational ideas in quantum mechanics including formalism, history, philosophy, and applications
- Utilize limited mathematical descriptions of ideas where appropriate
- Help students experience the utility of mathematical formalisms, empirical investigations, and deductive reasoning



Student Background

- Majors: philosophy, physics, chemistry, economics, music, psychology, history, others
- Mixture of comfort with quantitative analysis
- Philosophy background ranged from none to extensive
- Prerequisites
 - Conceptual physics course
 - Comfortable with algebra
 - Exposure to calculus



Physics Content

- Text: Grometstein, “The Roots of Things,” Kluwer, 1999.
- Topics: properties of light, Fourier analysis, the Young Experiment, blackbody radiation, photoelectric effect, atomic models, de Broglie’s hypothesis, the Schrödinger Equation, matrix mechanics, the Copenhagen Interpretation, alternative quantum mechanics interpretation



Mathematics Content

- Trigonometry
- Algebra
- Calculus
- Linear algebra
- Complex number theory
- Abstract algebra



Philosophy Content

- Process Philosophy
 - Hartshorn
 - Peirce
 - Whitehead
- Philosophical Stances
 - Realism
 - Positivism



Teaching/Learning Strategies

- Assigned readings
- JiTT
- ***Mastery quizzes***
- Classroom discussion and lecture
- Demonstrations
- ***Group and Individual Assignments***
- ***Group papers and presentations***
- Traditional Exams (problem solving and essay)



Mastery Quizzes

- Used in conjunction with tutorials on mathematics topics like functions, trigonometry, calculus, waves, linear algebra, and abstract algebra.
- Graded
- Unlimited retakes



Group and Individual Assignments

- Groups with mixture of students
- Encouraged collaboration (formally and informally)
- Good support of each other and peer instruction
- Generated excellent out-of-class discussions



Group Papers

- Required publication quality (identify journal)
- Groups involved mixture of students
- Peer Review
- Draft review to TA
- Class Presentations
- Final Review
- Publication Review



Student Reaction—Precourse

- High enthusiasm among honors students, philosophy majors, physical science majors, and former conceptual physics students
- Students with limited quantitative backgrounds needed assurance about level of mathematical expertise needed
- Students with limited philosophy backgrounds needed assurance of philosophy content



Evaluations

- Numerical Evaluations

- Intellectual Skills developed (upper 5%)
- Amount learned (upper 25%)
- Materials and activities effective (average)

- Comments

- Generally very positive
- More superlative comments than usual
- One negative comment



Content

- Interdisciplinary nature appreciated
- Group work helpful having students helping each other where they lacked expertise
- Some sensed we pushed students a bit hard on depth of philosophy and physics
- Appreciated being able to understand subject student had been told he couldn't
- Physics text widely praised
- Enjoyed look at fundamental physics assumptions



Learning Activities

- Group work helpful to support each other
- Synthesis paper very valuable
- Wanted more structure in philosophy
- Many wished for better integration of philosophy and physics topics



Positive Comments

“BYU MUST make more classes like this one!!! I think that classes like this are essential for a well rounded education...”

“This course was a highlight of my BYU experience!”

“Excellent course—one I’ll always remember! The success of this course rests in its interdisciplinary nature.”



Negative Comment

“Class was difficult, full of useless information, and a general waster of time. I want a refund. Thanks for wasting my life.”



Conclusions

- A challenging course in quantum mechanics can be successfully taught to general education students
- Physics can provide an avenue and motivation for these students to develop a facility with advanced mathematics
- Integration of physics and philosophy content is critical
- Group assignments are especially valuable in this kind of a course