

TEACHING QUANTUM MECHANICS

Peter Fletcher Department of Physics
 fletcher@phys.ksu.edu Kansas State University

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Methodology

- Stage 1 – **Grounded Theory Approach** used to develop a set of interview questions
 - Concept Maps (67)
 - Academic Staff Interviews (n=18)
 - Examination Scripts (137)
 - Preliminary Student Interviews (17)
- Stage 2 – **Phenomenological Approach**
 - One-hour Student Interviews (n=48)
 - Tabulated Dataset
 - 5 Themes

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Interview Questions

- Double Slit
- Duality - Ideas and Experiments
- Tunnelling - Barriers and Wells
- Instructor - Difficulties
- Linking - Shielding, Radioactivity, Real World
- Quantaroos - Quantum Kangaroos
- Epilogue

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Results – 5 Identified Themes

Theme	Description
1 <i>Types of Students</i>	Profile of the student <i>What is the student's base skill set and attitude towards the subject?</i>
2 <i>Entity</i>	Initial Viewpoint <i>What picture/idea is the starting point for that individual?</i>
3 <i>Potential Diagrams</i>	Specific Understanding of an Operational Tool <i>What is the students understanding of these diagrams?</i>
4 <i>Contextualization</i>	The Teaching/Learning Process <i>How do students make sense of the subject?</i>
5 <i>Difficulties</i>	The Teaching/Learning Process <i>What are the difficulties students face when studying quantum mechanics?</i>

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Wakeup Call #1

PRESENTATION

- 62% perceive that the course material in quantum mechanics is currently being delivered in compartmentalised chunks

Implication

- Students see no reason to integrate this material with other knowledge

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Wakeup Call #2

THE BIG PICTURE

- 30% of students discussed in detail that they were confused


Implication

- Students are not seeing a coherent 'big picture' for the discipline of quantum mechanics


"I was wandering, slightly confused, in the dark, for much of my undergraduate studies"

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Wakeup Call #3




NAME 3 APPLICATIONS OF QUANTUM MECHANICS?



- Only 25% were able to provide three (n=67)
- Post interview - all students commented that it was either 'scary' or 'outrageous' that the courses they had taken had not adequately prepared them to answer such a 'simple' question

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Wakeup Call #4




DESCRIBE RADIOACTIVITY IN TERMS OF QUANTUM MECHANICS?

- 50% of third years and 57% of fourth years did not, provide an answer, despite being prompted with the terms 'tunnelling', 'probability' and 'wave function'

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Wakeup Call #5

AN UNFAMILIAR POTENTIAL DIAGRAM




Discuss the likely behaviour of a quantum entity entering from the left.

- 70% were able to identify the features and provided a likely behaviour scenario
- Only 10% could describe how they would setup the problem to analytically solve it.

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Wakeup Call #6

QUANTUM ENTITY



A common assumption held by the lecturers is that, as the students progress they move to a probabilistic viewpoint


- Over 50% believe that a quantum entity sometimes behaves like a (classical) wave and at other times like a (classical) particle
- 20% wave packet
- The 'wave vs particle' view is persistent over time
- No indication this is a stepping stone towards a more sophisticated viewpoint

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Wakeup Call #7

MATH RULES

- 100% of students and lecturers said that good mathematical skills will get you a good mark




Implication

- Little incentive for students with good math skills to make complex changes to their schemata in order to gain a deeper conceptual appreciation

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Wakeup Call #8


VISUALIZATION OF MATH



- 50% said they cannot visualize the mathematics, it simply serves as a tool or a black box process

Implication

- There are two sides to this coin...



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Good Morning Class...

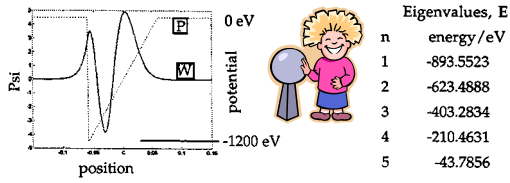


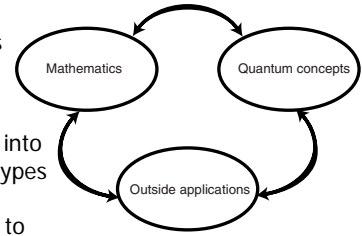
figure 1

"Honestly, if a student handed in a graph like that in any other subject they would be failed outright. Especially if it had a probability distribution drawn too... And we wonder why they get confused..."

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Future Research

- Mapping themes onto the three discipline areas
- An investigation into the nature and types of links present and/or available to enhance the process of teaching and learning



- An examination of the role analogies play in conceptual development

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