Perspectives in Quantum Physics: Epistemological, Ontological and Pedagogical

An investigation into student and expert perspectives on the physical interpretation of quantum mechanics, with implications for modern physics instruction.

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written by Charles Raymond Baily

has been approved by the Department of Physics

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The final copy of this thesis has been examined by the signatories, and we find that both the content and form meet acceptable presentation standards of scholarly work in the above mentioned discipline.

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ABSTRACT

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A common learning goal for modern physics instructors is for students to recognize a difference between the experimental uncertainty of classical physics and the fundamental uncertainty of quantum mechanics. Our studies suggest this notoriously difficult task may be frustrated by the intuitively realist perspectives of introductory students, and a lack of ontological flexibility in their conceptions of light and matter. We have developed a framework for understanding and characterizing student perspectives on the physical interpretation of quantum mechanics, and demonstrate the differential impact on student thinking of the myriad ways instructors approach interpretive themes in their introductory courses. Like expert physicists, students interpret quantum phenomena differently, and these interpretations are significantly influenced by their overall stances on questions central to the so-called measurement problem: Is the wave function physically real, or simply a mathematical tool? Is the collapse of the wave function an ad hoc rule, or a physical transition not described by any equation? Does an electron, being a form of matter, exist as a localized particle at all times? These questions, which are of personal and academic interest to our students, are largely only superficially addressed in our introductory courses, often for fear of opening a Pandora’s Box of student questions, none of which have easy answers. We show how a transformed modern physics curriculum (recently implemented at the University of Colorado) may positively impact student perspectives on indeterminacy and wave-particle duality, by making questions of classical and quantum reality a central theme of our course, but also by making the beliefs of our students, and not just those of scientists, an explicit topic of discussion.
ACKNOWLEDGEMENTS

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# TABLE OF CONTENTS

**Chapter 1: Perspectives in Quantum Physics**  

I. Introduction  
   A. Notions of Classical and Quantum Reality  
   B. Philosophy or Science?  
   C. Wave-Particle Duality and Ontological Flexibility  

II. Epistemology and Ontology in Physics Instruction  

III. Motivation and Overview of Dissertation Project  

References (Chapter 1)  

**Chapter 2: Development of Student Perspectives – Initial Studies**  

I. Introduction  

II. Studies  
   A. Student ideas about measurement change over time  
   B. Instructional choices influence student perspectives  
   C. Consistency of student perspectives  

III. Summary and Discussion  

References (Chapter 2)  

**Chapter 3: Quantum Interpretation as Hidden Curriculum – Variations in Instructor Practices and Associated Student Outcomes**  

I. Introduction  

II. Instructors approach quantum interpretation differently  

III. Comparing Instructor Practices (A Closer Look)  
   A. Background on course materials and curriculum similarities  
   B. Differences in instructional approaches
C. The double-slit experiment with single quanta 62
D. (In)consistency of student responses 65

IV. Summary and Discussion 67

References (Chapter 3) 69

Chapter 4: Refined Characterizations of Student Perspectives on Quantum Physics 71

I. Introduction 71

II. Interview participants and course characteristics 72

III. Refined characterizations of student perspectives 74
   A. Discussion of formal interpretations 75
   B. Students express beliefs that parallel those of expert proponents 76
   C. Categorization and summary of student responses 80

IV. Summary and Discussion 87

References (Chapter 4) 91

Chapter 5: Teaching Quantum Interpretations – Curriculum Development and Implementation 93

I. Introduction 93

II. Curriculum Development and Implementation 94
   A. Assessing incoming student perspectives and conceptual understanding 99
   B. Lecture Materials 106
   C. Homework 120
   D. Exam Materials 125
   E. Assessing outgoing perspectives 129
   F. Final Essay 136

References (Chapter 5) 138
Chapter 6: Teaching Quantum Interpretations – Comparative Outcomes and Curriculum Refinement

I. Introduction

II. Comparative Outcomes
   A. Student Interest in Quantum Mechanics
   B. Interpretive Attitudes

III. Curriculum Refinement and Other Future Directions
   A. Single-Photon Experiments
   B. Entanglement and Correlated Measurements
   C. Atomic Models and Probability

IV. Concluding Remarks

References (Chapter 6)

Bibliography

Appendices

Appendix A – Evolution of Online Survey Items
Appendix B – Interview Protocol (Spring 2009)
Appendix C – Selected Modern Physics Course Materials (Fall 2010)
Appendix D – Selected Homework, Exam, Survey and Final Essay Submissions from Four Students (Fall 2010)
Appendix E – Collected Excerpts from Student Reflections (Fall 2010)
Appendix F – Selected Student Discussion Threads (Fall 2010)