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1. Title (Maximum length 15 words) ***Research on the teaching and learning of quantum science***

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1. Title (Maximum length 15 words) ***Research on the teaching and learning of quantum science***

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Additional Form for Multiple Paper Sets
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3. Presentation titles and authors for the 3-5 individual presentations that comprise this multiple paper set. This information must be the same as the information provided on the individual cover sheets.

Presentation 1 Title ***Research on How an Intervention Using Computer Simulations in Quantum Chemistry Affect High School Students' Alternative Conceptions.***
Presentation 1 Author(s) Chuck Hurwitz, Gerald Abegg, Peter Garik

Presentation 2 Title ***Effect of Using Quantum Science Across Disciplines Software on Teachers' Pedagogical Content Knowledge***
Presentation 2 Author(s) Karen M. Robblee, Gerald Abegg, Peter Garik

Presentation 3 Title ***Students' Views of Models and Concepts in Modern Physics***
Presentation 3 Author(s) Manfred Euler, Andres Müller, Markus Hanselmann and Dean Zollman

Presentation 4 Title ***Students' conceptions of Quantum Physics***
Presentation 4 Author(s) Hartmut Wiesner and Rainer Mueller

Presentation 5 Title ***Evaluation of a New Approach in Quantum Atomic Physics in High School***
Presentation 5 Author(s) Hans Niedderer

Presentation 6 Title ***Quantum Mechanics: Exploring conceptual change***.
Presentation 6 Author(s) Peter R. Fletcher

Presentation 7 Title: ***A New Approach To Teaching Quantum Physics At High School Level***
Presentation 7 Author(s) Helmut Fischler

Presentation 8 Title ***Conceptual understanding of quantum mechanics after using hands-on and visualization instructional materials***.
Presentation 8: Dean Zollman and N. Sanjay Rebello

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Research on How an Intervention Using Computer Simulations in Quantum Chemistry Affect High School Students' Alternative Conceptions

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Research on How an Intervention Using Computer Simulations in Quantum Chemistry Affect High School Students' Alternative Conceptions. Chuck Hurwitz, Gerald Abegg, Peter Garik, Boston University

This study evaluates the efficacy of using computer simulations in overcoming high school students' misconceptions on the quantum nature of chemical bonds. We compare traditional methods of instruction such as lectures and laboratories to an intervention including interactive simulations and related activities in quantum chemistry. These simulations are developed under the National Science Foundation Grant Quantum Science Across Disciplines [QSAD]. Our goal was to determine whether the QSAD materials, in a setting of inquiry driven learning activities, alter student understanding. Our hypothesis was that students shift to a paradigm that uses explanations at the atomic level of quantum chemistry to explain macroscopic phenomena like melting point, vapor pressure, and solubility, as a result of the intervention. We used student concept maps and interviews to find the baseline conceptions regarding understanding of quantum science in chemistry. After the intervention high school students constructed concept maps and were interviewed. A comparison was made between pre and post interventions. The student interviews were coded and along with their concept map scores compared to the information obtained from students that exit a class using a traditional approach. We have data from chemistry students in three different high school classes, located in suburban Boston.

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1. Title (Maximum length 15 words)

Effect of Using Quantum Science Across Disciplines Software on Teachers' Pedagogical Content Knowledge._____

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Effect of Using Quantum Science Across Disciplines Software on Teachers' Pedagogical Content Knowledge. Karen M. Robblee, Gerald Abegg, Peter Garik, Boston University

The purpose of this study was to assess changes in teachers' pedagogical content knowledge as a result of their learning modern quantum science theory and using Quantum Science Across Disciplines (QSAD) computer visualization models in their instruction. Participating biology, chemistry, and physics teachers attended an intensive summer institute in which they investigated principles of quantum science and improved their own understanding of atomic and molecular behavior. Teacher participants developed activities for their students using computer visualization models. These activities were incorporated into the teachers' instruction during the following school year. Pedagogical content knowledge was measured using a modified Views-On-Science-Technology-Society (VOSTS) surveys, concept maps, teacher interviews, and classroom observations. Pre and post data indicate how teachers changed their views on the epistemology of science and the methods they used in teaching science as a result of improving their own understanding of quantum science.

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1. Title (Maximum length 15 words)

Students' Views of Models and Concepts in Modern Physics.

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Students' Views of Models and Concepts in Modern Physics. Manfred Euler, Andres M|ller, Markus Hanselmann, and Dean Zollman, Institut fuer die Paedagogik der Naturwissenschaften an der Universitaet Kiel (Institute for Science Education at the University in Kiel)

Important aspects of any study of modern physics are the use of models and a conceptual understanding of abstract ideas. Yet, our understanding of students' conceptual knowledge and use of models is incomplete. We have investigated aspects of this knowledge and the process by which students could change their views of models and concepts of quantum physics. Most of the students had completed a course in quantum mechanics. Yet, a pre-test indicated that the students' conceptual understanding was similar to secondary students. During the study the students completed a seminar in which concepts were emphasized. Included in the discussion were three models of the atom -- the Thomson Model, the Bohr Model and the Quantum Mechanical picture. Several post-tests were used to see how the students views of models and general conceptual understanding changed through the semester. The results indicate that many students were able to use the information, including the "incorrect" models of the atom to gain a broader view of contemporary physics.

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Students' conceptions of Quantum Physics

Hartmut Wiesner and Rainer Mueller, Ludwig-Maximilians University

Within the context of our project on Quantum Mechanics, we have interviewed German pre-service teachers after a Quantum Mechanics course. We investigated their ideas of the interpretative aspects of the theory such as their conception of atoms and their understanding of the meaning of the uncertainty relation. We present the results of these investigations.

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2. Title (Maximum length 15 words)

Evaluation of a New Approach in Quantum Atomic Physics in High School

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Evaluation of a New Approach in Quantum Atomic Physics in High School

Hans Niedderer, Stefan Deylitz, University of Bremen

Our teaching approach is aiming at a deeper understanding of an orbital model of atoms, molecules, and solids. The Schroedinger equation is used as a basis, both for a qualitative understanding and for making quantitative models using a computer modeling software (STELLA). A basic text for students and teachers has been written and used to train three teachers. The aim of this research was to evaluate how far students in these three classes have achieved the objectives of our approach. Data have been collected from a pre and post questionnaire and from final interviews. The results are that most students have changed from a particle- orbit view of electrons in atoms to an electron cloud view. Most students have developed a good notion of a quantitative electron distribution. Other objectives related to a better understanding of an atomic model, of the ψ-function, and the concept of a state have been reached sufficiently good, whereas a deeper understanding of the mathematics of the Schrödinger equation, a good understanding of the relation between theory and experimental results was achieved only by a smaller part of students (30% to 50%).

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Quantum Mechanics: Exploring conceptual change. Peter R. Fletcher, University of Sydney, Australia.

The purpose of this study was to develop a survey instrument to explore the conceptions that students hold after completing their first year studies in quantum mechanics. The survey comprised of four questions covering a selected number of fundamental concepts: the significance of the Photoelectric Effect, the meaning of Uncertainty, the nature of Waves and the nature of Energy Levels. The instrument was administered to 231 first year physics students at the University of Sydney in 1995. A phenomenographic approach was adopted, and supported by content, context and correctness analyses. The results suggested that new concepts presented in class are considered superficially and are quickly associated with other ideas in a student's current body of knowledge; the reintegration of inappropriately associated pre-existing concepts does not often happen; the development of mental models with time is minimal and that the majority of students retain their original secondary school models; and, students have great difficulty in using models to interpret data.

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1. Title (Maximum length 15 words) _____

A NEW APPROACH TO TEACHING QUANTUM PHYSICS AT HIGH SCHOOL LEVEL

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A New Approach to Teaching Quantum Physics at High School Level. Helmut Fischler, Free University of Berlin.

The learning of modern physics is made more difficult for students because teaching often uses semi-classical models (e.g. Bohr) and concepts (e.g. dualism). An introduction to quantum physics was designed which omits all analogies to classical physics. In the evaluation of the teaching unit, students' conceptions were recorded both at the beginning and the end of the teaching. Students in the test groups dispensed with visualized conceptions and reached an understanding which is more suitable to modern physics.

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1. Title (Maximum length 15 words) Conceptual understanding of quantum mechanics after using hands-on and visualization instructional materials.

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Conceptual understanding of quantum mechanics after using hands-on and visualization instructional materials. Dean Zollman, Kansas State University and N. Sanjay Rebello, Clarion University

The Visual Quantum Mechanics project teaches some basic ideas of quantum mechanics to high school and introductory college students by integrating hands-on activities and interactive computer visualizations. As part of field-testing we have investigated student understanding of several quantum concepts. These ideas include potential energy diagrams, energy levels and spectra in atoms, energy bands in solids, wave functions and probability, and quantum tunneling. The instruments of data collection include responses on tests and exams, semi-structured interviews which focused on students' understanding of a specific topic, and a concept map at the end of the course. The overall results indicate that students have acquired a good general understanding of some important concepts that are traditionally not taught at the introductory level and that the interactive computer visualizations and hands-on activities were critical in reaching this level of understanding.