Secondary school teachers discussing the pedagogical and cultural aspects in teaching-learning quantum physics

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Abstract. The instructional path and its tutorials of a teaching-learning proposal for quantum mechanics based on a Dirac approach and focused on building the theoretical thinking were used in a Master blended module for in-service teacher training. The proposal was discussed in a web laboratory and in a workshop proposed in-presence, warranting the personal involvement of forming teachers in concept analysis. We document enhancement of the competencies in order to discuss the crucial point of quantum theory and design instructional path centered on them.

Keywords: Quantum Mechanics, Teacher training.

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Quantum Mechanics (QM) constitutes the cultural reference paradigm for the description of the microscopic world, therefore its methodological elements can contribute to the construction of theoretical thinking and the formation of all citizens.

In literature, there is no common point of view for educational treatment of QM; different formulations and interpretations of QM has been used as starting points for different proposals. Three main approaches are followed: historical; construction of the formalism using analogy with classical situations; conceptual [1,2].

The 3rd one follows the vector approach, proposed by Dirac and adopted by many other authors. This approach is the reference for proposals in which the conceptual aspects of the theory on which one constructs the formalism and recognizes its role in QM are pointed out. Following this conceptual approach we developed a teaching-learning proposal for QM focused on building the theoretical thinking. It is based on simple experiments with polaroids and birefringent crystals in order to discuss the superposition principle and the quantum state concept [3,4]. Our proposal feasibility was tested in different secondary schools [5], and in pre-service secondary school teachers training [6].

The developed teaching-learning path and their tutorials were used in the Master IDIFO, coordinated by the University of Udine and realized with the cooperation of 15 universities for in-service teacher training on relativity and quantum physics. The proposal was discussed in a web distance laboratory and in a in-presence workshop. The formative module on Dicac approach to QM included: a) a on-line course on basic aspects of the theory (3 fc); b) an on-line course focused on the discussion of our approach and its tutorials (3 fc); c) an on-line didactical laboratory, in which the teachers produce a proposal based on the Udine-Dirac approach (1 fc); d) an in-
presence discussion about the knots of the proposal simulating an interaction with
students (September 2006 -1/2 fc); e) an in presence discussion addressed to
case conceptual and pedagogical main topics of QM (July 2007 - 1/2 fc).

In the following we consider the items of the final question and we present the

1. Elements characterizing/identifying the quantum behaviour. Pre (Pre-Test
answers): wave-particle dualism; Heisenberg relations; black body radiation; Frank-
Hertz/photoelectric effects. Post (final Questionnaire): Linearity and superposition;
Uncertainty and intrinsic probabilistic behaviour of measurement processes;
Incompatibility and Uncertainty principle.

2. Possibility to make previsions on measurement results. Pre: Only in a
probabilistic way [without any other explanation]. Post: Discussion using simple
examples of the quantum probabilistic prediction, according to the superposition
principle, stressing the role of the scalar product; sure results preparing the system in
an eigenstate; correlation of results with entangled systems (un-separability).

3. Knowing the property of a system implies the existence of this property? Pre (in
the Web discussion): a quantum state is like a state of a macroscopic system with not
well perceived properties; or: we can attribute a property to a system only after a
measurement. Post:(All); Discussion on diverse levels, according to different
interpretation (orthodox framework; alternative bohemian scheme).

4. Base concept that must be included in a learning/teaching proposal on QM. Pre:
Black body; photoelectric effect; uncertainty relations. Post: conceptual aspects;
superposition principle, state, incompatibility(all); entanglement; different meaning
of the superposition principle in QM and in classical physics; intrinsic uncertainty;
Applications of QM proposed only after conceptual aspects have been treated.

The documented changes show enhancement of the forming teachers competencies
on nodal concepts of QM. The crucial aspect of change was the personal involvement
in the analysis of the concept during the module. At the educational level, teachers
evidenced a radical change: in the pre-test the teachers consider prevalently the old
physics of qua as topics for an educational proposal; at the end of the formative
path all of them propose to analyze the conceptual aspects that found the theory with
students. Their attitude changed because they experienced the feasibility of the
experiments, of the conceptual path, of the simple mathematical adopted formalism.

REFERENCES

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