

A Research Based E-Learning Process for Teacher Formation on Quantum Mechanics

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Abstract

A deep reflection in the reconstruction of the basic concepts is crucial for teachers when a conceptual change in the way of thinking about phenomena is involved, as in the case of teaching/learning Quantum Mechanics (QM). Metacultural, Experiential and Situated integrated modalities were implemented in the last years in a e-learning Master module on QM for personal involvement of teachers in building Pedagogical Content Knowledge (PCK). Different learning path in the construction of CK and PCK on QM emerge in the discussion of the web community of in-service teachers.

1. Introduction

Teaching modern physics, and in particular quantum mechanics (QM), in Upper Secondary School, although included in the national curricula on many nations [1], is still a research subject of debate, for specific topics to be treated; approach to follow; formative objective to be aimed [2-4]. Teachers teaching QM do not have clear reference. Therefore they often evidence: simplified approaches; insecurity in treatment of the topics; lack in aspect of subject (CK), of didactic (PCK) [5-6], of active use of lab and ICT (TPCK).[7-8]. In particular, the introduction of innovative approaches finds further obstacles in the tendency of teachers to put attention only on exhaustive and propaedeutic aspects of classical physics, without give a modern view of it, to include, as an appendix, pills of modern physics, without a coherent treatment, do not proposing the cultural value of the modern theories and adopting approaches that do not produce effective learning [2-4, 8-9].

Hint for teacher formation for innovation, in the perspective of MER [10] as a way to look at Shulmann PCK [11], is to include activities of reflection on cardinal concepts of the theories, reconstruction of the interpretation of the phenomenology, comparison of different proposals about teaching/learning QM, analysis and reflection on students learning knots and their typical learning path approaching QM [2-4, 6]. An hypothesis of the present work is that these activities can usefully be carried out using the tools of communicative interaction in a web-network. This paper gives a contribution, related to the specific topic, in the direction of the research objective to explore the role played by multimedia sources available on the web and in particular e-learning activities for individualization of learning process using and enhancing simple tool as Web-forum; Collaborative writing instruments [12-13] for deep analysis, a-synchronous discussion, cooperative learning aims to the construction of an unitary picture of specific subject on study and design [12]. Moreover we want to explore in which way the needed integration of metacultural, experiential, situated phases in the teacher formation [14-15] can be realized and enriched by the network sharing of: problems encountered in the preparation of intervention; typical students difficulties of learning paths; materials used [2-6].

In particular this paper gives answers to the following Research Questions::

RQ1. What role does plays the computer network in the formation of teachers in teaching innovation in particular on QM?

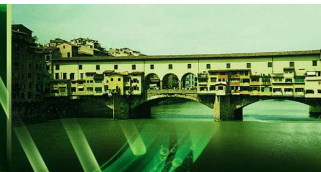
RQ2. How web-forum discussion contributes to the achievement of educational objectives?

RQ3. Critical aspects?

In the context of a II level Master offered to a selected group of Italian physics teachers a formative module on QM was designed. Here the context of the Master and the formative module on QM, will be discussed analyzing the results emerging form the web interaction.

2. The II level (post grad.) Master IDIFO3 and the sample

The II level biannual Master IDIFO 3 (<http://www.fisica.uniud.it/URDF/laurea/pls3.htm>) was instituted by University of Udine in 2011, with the collaboration of other 18 Italian Universities and the National



Lab of INFN. 48 teachers selected from all the Italian regions attended the Master. The aim of the master was to prepare upper secondary physics teachers to: theoretical thinking on which modern physics and formative guidance. The Master included 26 e-learning courses offered to all the participants, and 21 courses in presence offered at local level. An U-portal platform supported the educational web-environment (<http://idifo3.fisica.uniud.it/idifo3/render.userLayoutRootNode.uP>)

The QM Module in the Master was structured in three main courses: A1-Course: The new way to think to QM and the Dirac formalism (analysis and discussion on the web of the teaching/learning proposal on QM (reference proposal hereafter) [16-18]; A2 Course: conceptual knots of QM (Starting from the analysis of the questionnaire on QM knots filled in A1, discuss the main conceptual knots with the aim of design proposals for experimentations in upper secondary school); A3 Course: Proposals teaching quantum physics: a comparative analysis (a comparative critical discussion of research based proposals in literature starting from research reviews [2,9,19]. The sample here considered is composed the 22 student teachers (12 graduated in physics, 6 in mathematics, 2 in engineering) attending the A1-A2-A3 courses, with great expertise in teaching at school level.

3. The web implementation of the three courses on MQ

The course A1 was divided in three stages. In the first (02-12 Feb. 2011) the student-teachers analysed and discussed in the web forums the papers presenting the reference proposal [16-18] and the web site designed as support for teachers formation and educational repository on that proposal [20]. The debate has been developed on two levels: first the level of the cultural and conceptual choices; second the didactic/pedagogic level. The second stage (10-14Feb.2011) concerned the critical analysis of the tutorials, which translate operatively the proposal and are integral part of it. The experiential training to use them, as did the students who have experienced (now in over 20 classes) brought out the thread of reasoning in each step and offered the chance of discussing the most important aspects of the new way of thinking of theoretical physics. The third stage (15-20 Feb. 2011) was devoted to discuss content and teaching methods in the perspective of the educational design.

The discussion in the three modules of the A1 courses was structured in six forum (WF1-6). Here we stress on the first that is the object of analysis.

WF 1) The choices made: cultural significance and limitations. The aim was to analyse the value and the limitations of the proposal on the cultural level, in light of other known paths and in particular on the proposals already followed the course of QM in comparison. Two requests: A) a personal perspective stating from the reference proposal; B) ideas emerged from the comment of colleagues.

The other WF focalize on the choices made in the curriculum, the educational instruments used [16-17, 21], the concepts that are learned and criticism, relation between real and ideal experiments and role in the proposed educational path and other fields of physics, design educational project.

The course A2 was based on the analysis of different proposal on QM at undergraduate level, starting from review papers [2-3, 9, 19]. The course A3 was structured on the analysis of knots in QM.

4. Instruments

Sources of data for the analysis are: the contributions in the different web-forum and documents uploaded. The hypothesis is that the peer to peer collaboration constitute an added value in particular when facing conceptual knots in QM, typical learning problems of students, discuss the knots of the reference educational path; cooperative learning on the web, based on the discussion of research based documentation of educational path produce acquisition of CK and PCK.

The analysis of the web-discussion was performed on different levels that involve different dimensions of the interaction in a virtual environment. In particular we consider: the frequency of contributions; time evolution of interventions; tree-roots analysis of the contributions; contents-roots connection. The evaluation of cooperation level was performed classifying the typology of contribution according the taxonomy of Hara, Bonk, Angeli [22], integrated for contents by Hrastinski [23], in particular for what concern the passage of the collective knowledge from implicit (possessed by single) to explicit knowledge (shared in the dialogue), elaborated knowledge (by inferences and judgments), re-interiorized knowledge (projects): A- Answers (contributions centered on explicit answers); EC – Elementary clarification (single/simple pertinent observations or comments); DC - In-Depth Clarification (relevant observations or comments, which show the acquisition of a thorough understanding of the discussed knots); II – Inferencing (it manifests development of the topic under consideration); J – Judgment (there are decisions supported by document or motivated assessments); INF- Notification of uploading; OT - Off-topic; S- Salutations. For the Categories A-EC-DC was



identified also the following subcategories: -C Content related; ...-D Didactic related; -TO Organization & Technical aspects related.

To evaluate the amount of interaction in the web-forum, the adjusted mean reply depth (ρ') [24] was used, here defined:

$$\rho = \sum_{i=1}^m n_i w_i$$

$$\rho' = \left(\frac{N-b}{N} \right) \sum_{i=1}^m n_i w_i$$

where N= total number of contributions, b= initial contributions without development, n_i = numbers of contributions at level I, w_i = weight of the contribution level ($w_i=(i-1)/N$)

The last level of the analysis was performed on the subjects of the contributions, as in a previous research on teacher formation on the web [25-26].

5. Data

First of all we consider the interaction in WF1. 14/22 student-teachers contributed to the WF1, with N=27 contributions. Each students-teacher contributed with a minimum of 1 to a maximum of 4 interventions, with a mean value of 1.9 ($\sigma=0.8$). The tutor has set up the forum, assigned the task and leaved free the discussion between peers. The graph of Fig. 1) shows the sequence dynamic of the discussion, where 9 students/teachers contributed with 2-3 interventions.

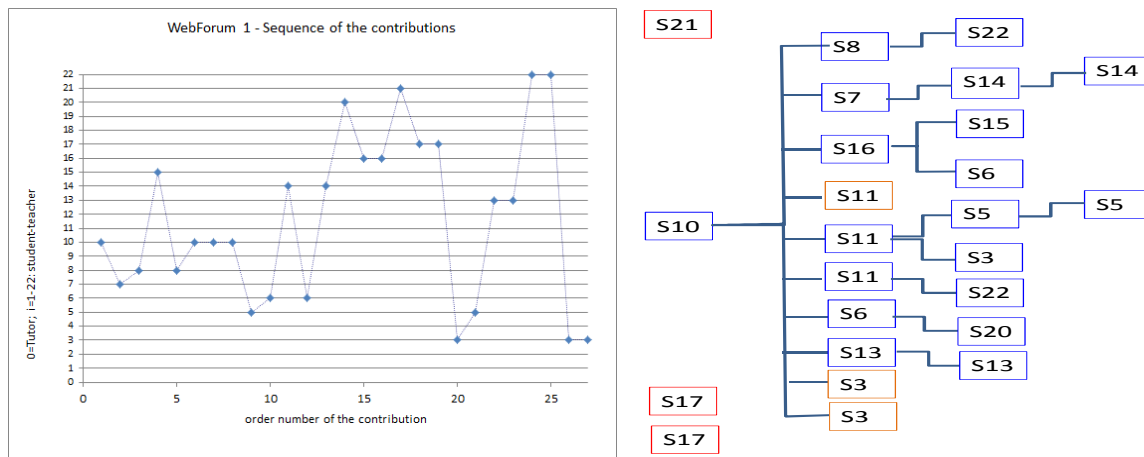


Fig.1 – Sequence of the contributions in the web-forum 1 of the course A1 (on the right) and tree structure of the web discussion in WF..

The tree diagram analysis (Fig. 1) evidence that the contributions of the student-teachers started only from one of the four initial contributions posted in the WF 1 and are organized in 7 branches (from 1 to 3 ramifications). The mean reply depth is equal to $\rho'=1,4$ and the mean number of links was 0,9. The two analysis show a low grade of interaction in the forum, that is not confirmed considering the contents of the posts. The typology of contributions, analyzed according to [27-28], are synthesized in fig. 4, where the mode (1/2 of the contributions) correspond to elementary contributions, and 1/3 of the contribution are of the deep contributions category. In any case the focus is on didactic. For the student-teachers, the cultural value of the referent proposal on QM is related to the educational choices done, and for less to the choices of content and theoretic approach.

The correlations appear considering the subject contents of interventions of different roots. For instance three contributions stress in very similar way the effectiveness of the referent proposal: S21- Evaluation of the proposal: similar to other analyzed; “Positive because independent from interpretation”; S10 – “The path is similar, at least in the beginning, to two paths [27-27] that I analyzed in the course A3. I had chosen as "attracted" by the type of approach, which reflects that of the proposal”, S17- “effectiveness for learning, need to integrate with other examples”.

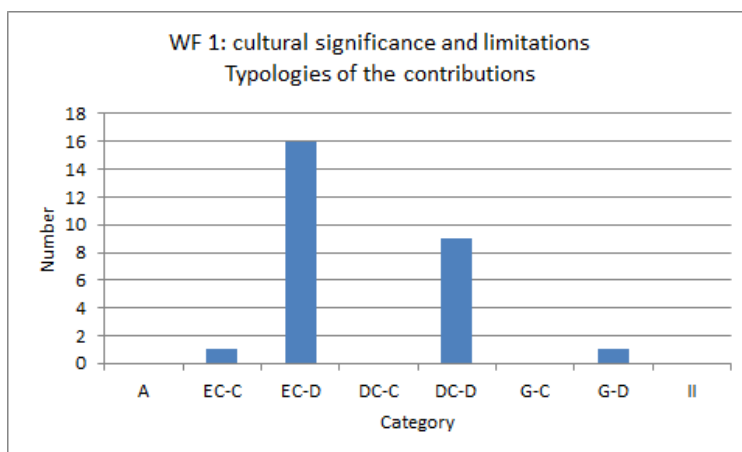


Fig.2 – Classification of the contributions: absolute frequencies of the typologies.

Moreover two contributions stress that the reference proposal treat the core of the theory starting from simple experiments and breaking with classical physics, aspect emerged in other five contributions. Finally, two contributions stress on the critical point of the path concerning the need to motivate the existence of photons: S20 and S3-“Müller, Wiesner [28] treat the photoelectric effect in order to introduce the concept of the photon, while in Michellini Santi Stefanel [21] the fact that light is composed of photons is taken as a knowledge that pupils need to have”.

The richness of the web discussion emerge looking at the contents of the posts both regarding the value of the reference proposal for students learning, the context of light polarization phenomenology and both for what concern suggestion on how integrate the educational path: need to generalize (other contexts suggested: double slits; Mach & Zender – 4 cases); lack about Schrödinger Equation (2); lack of application (1), historical review (almost at the end(1).

6. Conclusions

In the context of a second level Master a formative module for physics teacher on QM was designed. It was structured in three e-learning courses, centred on a research proposal focused on the basic principle of QM using a Dirac approach to the concept and the basic formalism. 22 selected student-teachers from all Italy attended the entire module. We hypothesized that the web e-learning environment can favour the development of CK and PCK as well, in particular in the case of the QM, for which the teacher need to go deep in the concepts, as well in the new proposals for high school, in the students learning problems and educational strategies activating involvement of the students in their own learning path. To obtain a complete overview on the web interaction, we analyzed the interactions on the web-forum using different methodologies and instruments. The interaction in the web-forum using standard methodology, as the analysis of the sequence of the contribution, the tree analysis, the evaluation of the number of the link and of the depth of penetration index evidence low grade interaction. A rich interaction appears at the dimension of the contents, being shadowed in the electronic interaction and undetectable with standard method of analysis of the posts of the students-teachers in the web-forums. At the same time the multilevel analysis here conducted allows to obtain a multidimensional overview on the role played by the interaction in web-forum in the acquisition of PCK in the case of the forum analysed here.

From the multilevel analysis we can conclude, that attending the course on the web a cooperative learning is activated also when the explicit level (for instance low number of link, low index of depth). A rich interaction was obtained on the base of defined requests to the student-teachers, research based materials proposed as reference materials to the student-teachers (RQ1). The student teachers attending the course evidence an initial great attention to the educational level, moving progressively to the concepts. The cooperative learning, activated by simple instrument as forum, appears particularly effective to reach a sharing vision on relevant aspects of QM in secondary school, enhancing the personal attitudes, facilitating the acquisition of competencies in the discussion on QM basic concepts, link of related CK and PCK (RQ2), Moreover, the a-synchronous interaction activated, replacing the meetings in presence”, leave more freedom of time the student-teachers and stimulate the production of contributions emerging from a personal reflection on the topic discussed.



At the same time some concern regards the following points: tendency to focalize the discussion or on the conceptual level, or on the educational level, just in few cases merging the two aspects, or better contributing at the same level on the two; tendency to not stress the differences between educational proposals based on different approach; need of a blended modality to implement in effective way an innovative proposal and to design IBL educational tutorials for students (RQ3)

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