Results of a Galilean Physics-of-motion Teaching Case Study

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Abstract. This paper is based on previous works [1, 2] and is an extension of my doctoral thesis [3] completed at the University of Lille under the direction of Prof. Raffaele Pisano. A comprehensive course on the Galileo's physics of motion was implemented in curricular time with particular emphasis on laboratory activities. A questionnaire was administered before and after the teaching activity held at the *Liceo scientifico 'F. Sbordone'* in Naples, providing important results on the effectiveness of the educational historical path and more generally on the Nature of Science (NoS) Teaching [4].

Aim of the work and research questions

The main objective of this work is to incorporate Nature of Science into the physics curriculum in order to increase students' interest in science. In particular, the experimental and theoretical elements of Galileo's physics that can be taught in a scientific high school were investigated. The effects of a history-based curriculum on students' understanding of physics concepts and motivation were also analysed.

The analysis of historical documents and the design of the educational path

The analysis of Galileo's writings, especially his laboratory notes archived at the *Biblioteca Nazionale Centrale di Firenze* [5] and his Kinematics (and Building sciences) foundation work *Discorsi e dimostrazioni matematiche intorno a due nuove scienze attinenti alla meccanica e ai movimenti locali* [6] led to the development of a history-of-physics educational path. Experiments of particular historical interest were reproduced under the same experimental conditions under which they were first carried out [7]. The main topics involved were: 1) free fall motion, 2) falling motion in fluids, 3) pendulum motion, 4) uniformly accelerated motion along an inclined plane, 5) motion of a projectile. The educational experimentation was conducted over three years and involved more than one hundred students aged between fourteen and sixteen from six classes (two from the first year of secondary school, two from the second year and two from the third year).

The entry/exit questionnaire and conclusions

A mixed questionnaire with open and closed answers was prepared. It consisted of two parts that were administered to the students in separate sessions.

The first ten questions (and twenty-five sub-questions) are conceptual ones, Force Concept Inventory type questions [8], because they aim to examine students' understanding of physics topics. This first part of the questionnaire was used to assess both the students' initial conceptions and the acquisition of skills achieved after participating in the educational activity. The comparison of the results for the different grade years of high school also provided interesting results on the curriculum, especially on the required mathematical knowledge, especially on parabolic motion.

The second part of the questionnaire consists of twenty-nine closed-ended questions with twenty-nine optional open-ended sub-questions designed to clarify what was specified and a final open-ended question. These dealt with motivations and interests in the fields of physics and mathematics. By comparing the answers given by the students in Likert-type scale [9] before and after the educational activity, it was possible to assess the effectiveness of the educational course on the students' beliefs. Wilcoxon Signed Rank Test [10] was used because the data (answers from a questionnaire before and after the learning path) are paired and the applicability conditions of parametric tests were not met. After rigorous statistical analysis, there was significant evidence that students had changed their understanding of Nature of Science, taking into account the changes in their answers to the questions "I am very interested in physics as an experimental science" and "I am very interested in the context in which physics has historically developed" [3]. As an in-depth study, the effect size [11] of the educational process on students' interests is calculated, taking into account differences in gender, skills acquired and upper secondary grades, finding for example the importance of performing physics experiments first-hand especially for female students.

References

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