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The educational role of a scientific museum: a case study

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Abstract. The purpose of this work is to present an ongoing physics education project based at the Museum of Physics of the University of Turin, whose goal is studying the educational significance of the history of physics. The major targets of this project are: compiling a census of the collections of instrument of historical-scientific interest preserved by a significant sample of schools in Piedmont, Italy; designing experimental activities rooted in the development of the physics instruments displayed in the Museum and in the school collections detected; finally, testing the efficacy of these activities.

1. Background

The Department of Physics hosts the Museum of Physics of the University of Turin, preserving a collection of about 1300 physics instruments, the oldest of them dating back to the early 1700s. The Museum of Physics was established in 2009, to preserve the collection of scientific instruments of the former Physics Cabinet of the University, and belongs to the University of Turin Museum System (SMA). The Museum of Physics is very attentive to the issues of cultural heritage protection and diffusion of the scientific heritage (e.g. in 2018 the Museum participated to a microclimatic study aimed at assessing the microclimatic quality of its main exhibition hall) (figure 1) [1].

The historical collections preserved by University-based physics museums, such as the Museum of Physics in Turin, are usually made of instruments originally acquired for teaching *and* research. Yet, the sad state of affairs of most of these collections is that these instruments are by and large unused *neither* in research (a wholly understandable thing) *nor* in teaching (and this is far less understandable). This state of affairs is made even more sad by the growing awareness in the science education community of the science education functions of science museums [2][3] as well as of the advantages of introducing history of science topics into the teaching of science. [4][5]

To partially reverse this state of affairs, we have launched a collaborative effort between Museum of Physics of the University of Turin and the old Cabinets of Physics of a significant sample of secondary schools in Turin and Cuneo provinces, in northwestern Italy. [6] It is our hope that this effort, which is part of the PhD project “Toward an integrated Museum of Physics”, will serve as a catalyst to the rescue, preservation and diffusion of the scientific heritage and can play a seminal role in transforming dusty and directionless sets of display cabinets into tools of education. [7]

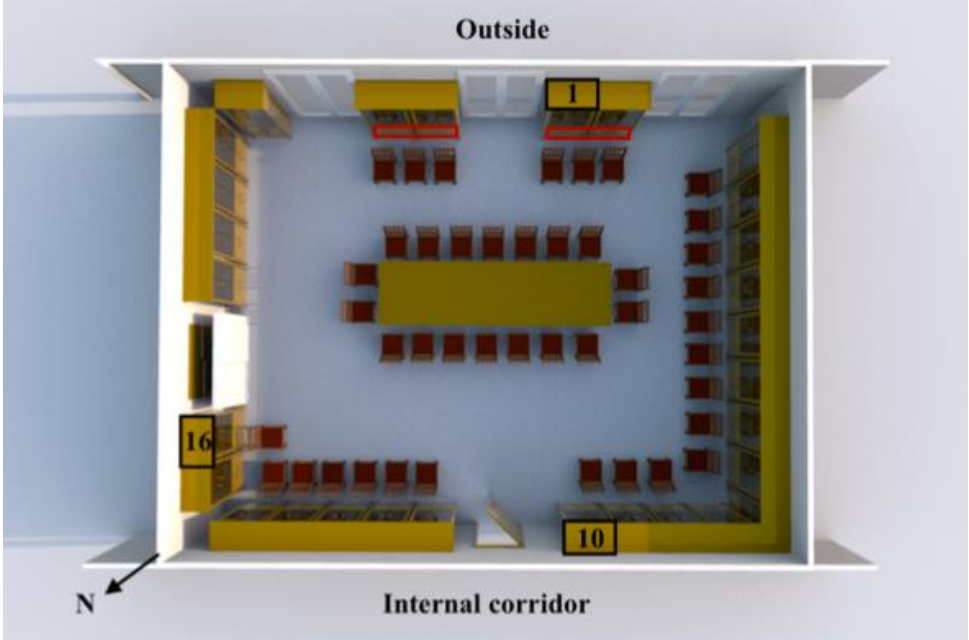

Figure 1. Scheme of the exhibition hall of the Museum of Physics, University of Turin, subjected to the microclimatic study.

2. The census

The project started with a census of the collections of physics instrument of historical-scientific interest preserved by the most ancient public and private secondary schools in the selected provinces. Out of this sample we have so far identified 17 nineteenth century classical lyceums and gymnasiums preserving significant collections of scientific instruments that were formerly part of the school's old Cabinets of Physics. 12 of these schools are located in Turin province and the remaining in Cuneo province (figure 2, figure 3).

These collections, amounting to several thousands of instruments, form a varied landscape since they are very diversified in terms of size, state of conservation of the instruments, degree of cataloguing and actual use for educational purposes. We have found indeed that the school collections can be classed into four classes according to their degree of organization and maintenance:

1. instruments stored in boxes in school closets and no longer used (e.g. Lyceum Baldessano Roccati and Lyceum Sociale)
2. instruments stacked in furniture or shelves in the laboratory, without cataloging or paying attention to the exhibition (e.g. Lyceum Alfieri)
3. instruments in part exposed in showcases and sometimes shown during lessons (e.g. the very rich collection of Lyceum Govone in Alba, whose instruments are in part displayed in showcases along the corridors of the school and in part are shown to the students during the physics labs)
4. real school museum, open to visitors, at fixed times (notable examples of this class are the MuBec, the Beccaria Museum within the Lyceum Vasco-Beccaria-Govone in Mondovì (Fig. 3), and the Museum of Natural History "Don Bosco" in the Lyceum Valsalice, Turin)

Though the quantitative analysis of the collections surveyed is still ongoing, this census has

highlighted a number of very interesting issues, not least of which are the relationships between these collections and the collection held by the Museum of Physics, University of Turin. A case in point is the spread throughout the surveyed schools of instruments made by E.F. Jest and C. Jest who, besides having a reputation of skilled craftsmen, were the official instrument makers of the University of Turin. Another case in point is the identification of instruments formerly owned by one of the "fathers" of experimental physics in Turin, G.B. Beccaria, who, in the second half of the eighteenth century, was responsible of a major renovation in the physics research at the University of Turin through significant contributions to the study of the properties of electricity. Interestingly, though Beccaria held the chair of physics (in the years between 1748 and 1781) and though the old inventory of the former Cabinet of Physics of the University lists a number of 1700s frictional electrical machines, the Museum of Physics of the University is conspicuous by its lack of any of these instruments. However, it was encouraging to find out that a fine example of Beccaria's frictional electrical machine is preserved by the above reported Beccaria Museum of the classical Lyceum in Mondovì (figure 5).

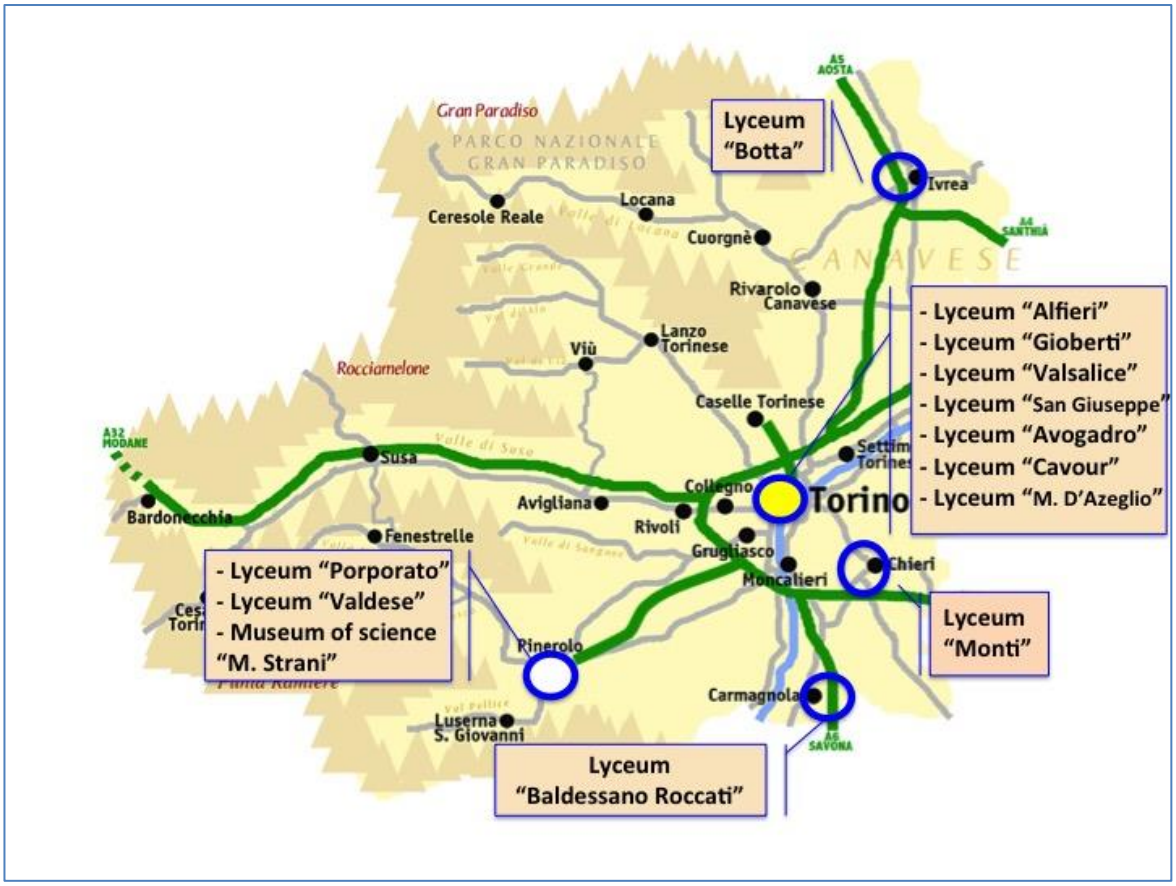

Figure 2. Classical lyceums surveyed in the Turin province

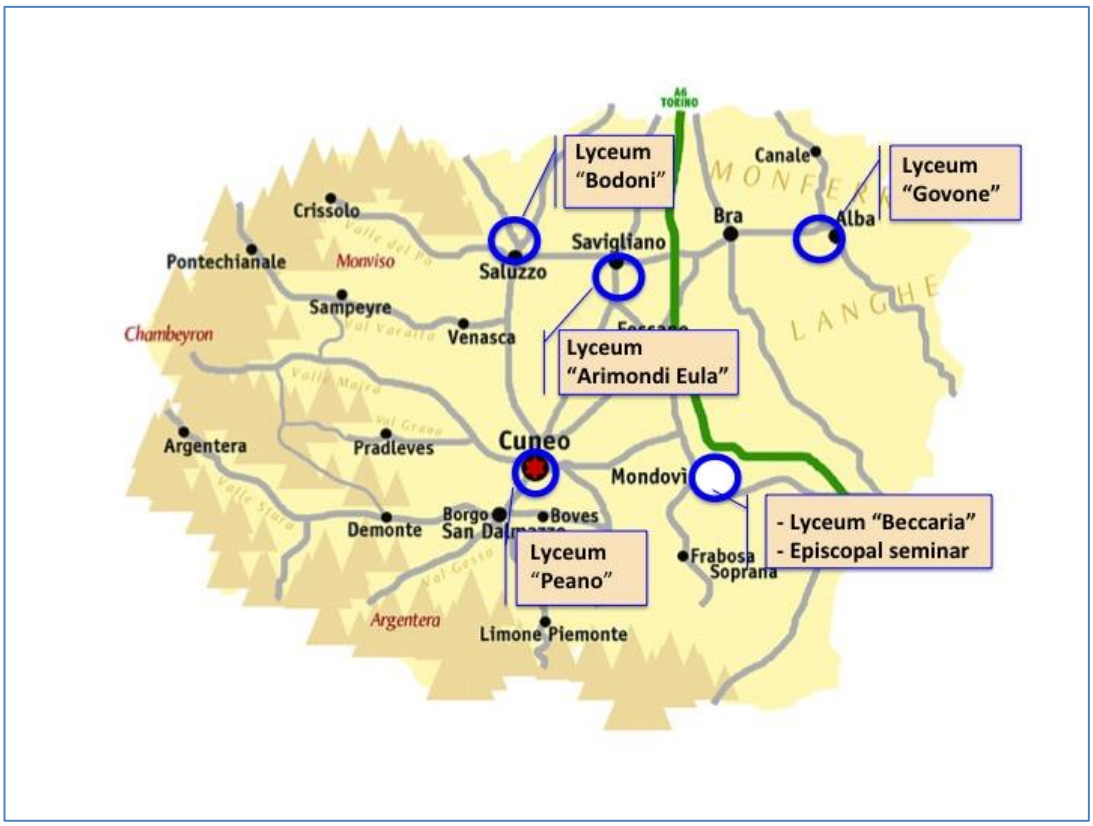

Figure 3. Classical lyceums surveyed in the Cuneo province

Figure 4. Main hall of the Beccaria Museum within the Lyceum Vasco-Beccaria-Govone in Mondovì

Figure 5. Beccaria's frictional electrical machine preserved by the Beccaria Museum in Mondovì

3. The survey

The second part of the program is aimed at designing and testing experimental activities rooted in the development of the physics instruments displayed in this "integrated museum", that is both in the Museum of Physics and in the collections detected by the census.

As a first step of this part of the program, we investigated the motivations that drive (or discourage) the choice of using the historical approach to introduce scientific themes and concepts. A number of arguments have been indeed put forward to support the use of history of physics in physics education. For example, history of physics and the wider domain of the history of material culture as represented by the collections of old scientific instruments in schools and universities may prove to be useful at the meta-cognitive level. It was indeed argued that the collaboration between school and science museum might promote achieving both cognitive and emotional student outcomes [2][3][8]. However, despite the positive educational effects of the history of science, an apparent change in science teachers' attitudes towards it and the availability of history of science teaching resources, "its occurrence in

science classrooms is limited". [9] [10]
With the goal of understanding the possible motivations behind this limited occurrence, since Spring 2017 we have been administering a Likert scale questionnaire to a sample of (mainly) secondary school in-service teachers participating to a number of training seminars in physics education organized by the University of Turin, Italy (size of the sample = 156). A 1 to 5 scale was used, where 1 corresponds to complete disagreement and 5 to perfect agreement. By this anonymous questionnaire we probed the teachers on three areas: (1) usefulness of the historical approach; (2) meaning of the historical approach; (3) teacher's self-assessment of expertise
The analysis of the questionnaires has shown a substantial agreement of the teachers involved in the administration with the view that it might be helpful to bring a historical approach to the normal disciplinary teaching. Although most of this sample of teachers were confident that the preparation they had obtained by self-study research was adequate (answer C), most of them felt that they had not received an adequate preparation in history of physics for educational purposes during the undergraduate (answer A) and postgraduate (answer B) years (figure 6).

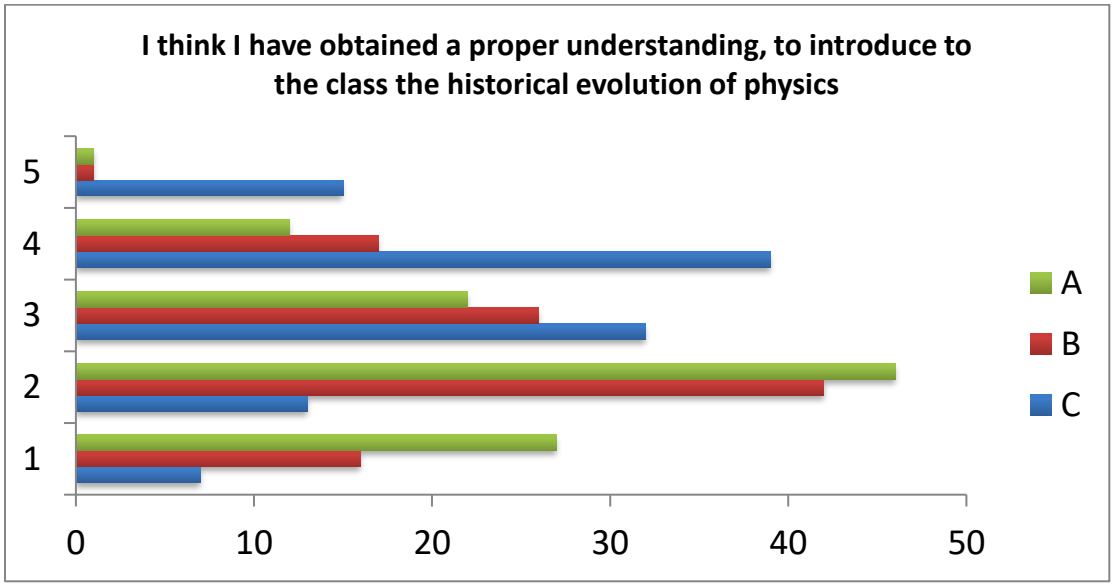

Figure 6. Teachers' self-assessment of expertise on the history of physics as an educational tool

After the analysis of the questionnaires and the dialogue with some teachers we have proposed training seminars [11][12] about:

- Set up and organization of a school museum
- Analysis of students' prior knowledge
- How to prepare a didactic activity using an historical approach

4. The integrated museum

Besides exploring teacher's motivations toward the historical approach, the second part of this research program studied the power of an "integrated museum of physics":

a) in providing insights on student's prior knowledge concerning the physics contents embodied in a given set of physics instruments displayed in the Cabinets of Physics, and

b) in promoting the learning on the same physics contents through hands-on activities with low-cost materials obtained by artifacts inspired on the physics instruments displayed in the Cabinets.

As for point a), student's prior knowledge is studied through questionnaires specially designed with items inspired on the history of physics. The students are indeed posed the same conceptual questions that the scientists of the past had to address.
For what concerns b), the activities performed in the schools are largely dependent on the current state of organization of the local cabinets of physics, that is experimental activities inspired by the local collection when this one is relatively well surveyed and catalogued, or census of instruments and historical research on the physics behind the instruments when the collection has not yet reached an adequate level of organization. In both cases the students are expected to be active protagonists of the designed intervention.

5. Conclusion

So far, the project here discussed has revealed a number of interesting points. First, the census has evidenced a substantial heritage of historical scientific instruments of potential educational value. Second, the preliminary results of teachers' questionnaires suggest that the teachers more active in the in-service training activities do not question the validity of the historical approach but, rather, fear that factors like the lack of time or the lack of adequate preparation in the undergraduate years might compromise the outcome of this approach. Finally, the analysis of the educational significance of the experimental activities carried out in Museum and schools has yet to be probed in full since the project is still ongoing. The preliminary results, however, suggest that the history of physics plays a relevant motivational role in the physics learning.

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