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Should the history of physics be rated X? A survey of physics teachers' expectations

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Abstract

Over the past few decades a growing awareness has developed in the science education community about the educational power of the history of science. Yet, the historical approach is not implemented in many ministries of education policies. In order to investigate what factors contribute to this, we have conducted a survey of attitudes toward the history of physics amongst a large sample of Italian secondary school physics teachers who received in-service training programs in physics education. In particular, we have explored teachers' opinions about the meaning and usefulness of the historical approach, as well as their self-assessment of expertise. We have found that these teachers do not question the validity of the historical approach. A minority of them, however, fear that factors like the lack of adequate preparation in the undergraduate years might compromise the outcome of this approach.

Introduction

One of the most widely read and cited papers on the topic of history of science for science education was published on *Science* in 1974. In this paper, provocatively titled 'Should history of science be rated X?', its author (S G Brush) argued against the use of 'historical materials of the kind now being prepared by historians of science' since they will not serve the purposes of positively affecting student's learning of science and about science [1].

Over the past few decades much has been written on this topic and a growing awareness has developed in recent years in the science education community of the advantages of introducing history of science topics into the teaching of science among students and pre-service teachers [2] as well as of the educational power of science museums [3]. Notwithstanding this awareness, this approach is not implemented in many ministries of education policies (e.g. only scant references are made to this approach in the Italian National Guidelines for the primary and secondary education [4]) and remains largely unadopted by many physics teachers [5]. In order to investigate what factors contribute to this state-of-the-art, we have conducted a survey of attitudes toward the history of physics as a physics learning tool amongst a sample of Italian secondary school physics teachers who received in-service training programs in physics education. The basic purpose of this survey was to understand whether the current situation reflects their stances towards this issue.

1. History of physics for physics education

A number of arguments have been put forward to support the use of history of physics in physics education. For example, the history of physics might be a useful tool to help identify and possibly overcome, the mental representation of students on physical science topics [6, 7]. The 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 also prove to be useful at the meta-cognitive level. It was indeed argued that the collaboration between schools and science museums, i.e. between formal and informal education, might promote achieving both cognitive and emotional student outcomes [3, 8, 9]. One of the teaching formats that has been elaborated upon and evaluated by the science education researchers is just 'conducting historical (thought) experiments or replicating actual laboratory procedures, tracing the development of scientific methods, concepts and theories' [10] (see also [11, 12]). Furthermore, 'historical approaches in science education offer substantial benefits in enabling people to develop scientific literacy and an understanding and appreciation both *in* science and *about* science' [13, 14].

As is evident from the above, much has been written about the educational role of the history of physics. So, we know rather a lot about the widespread opinion among a subset of the science education community. Much less, instead, is known about the opinions on the perceived feasibility and effectiveness of the historical method as a teaching tool of those who should implement the results of the educational research, i.e. the physics teachers.

2. The survey

As was recently emphasized, despite the expected 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' [13]. According to some researchers, while the teachers 'who believe in and practice the inclusion of the history of science identify many benefits for their students' [15], and while some science teachers see history as a tool for fostering process skills and for illustrating the procedural aspects of real science, 'they seem to lack the professional knowledge, epistemological background and confidence to use [history of science] to support conceptual learning and to reflect on the contexts and nature of science' [10].

In order to investigate the motivations that drive (or discourage) the choice of using the historical approach to introduce scientific themes and concepts, since Spring 2017 we have been systematically administering a Likert scale questionnaire to the teachers participating to the training seminars in physics education organized by the University of Turin, Italy. A 1–5 scale was used, where 1 corresponds to complete disagreement and 5 to perfect agreement. By this anonymous, pencil-and-paper, questionnaire we probed the teachers on three areas: *usefulness* of the historical approach; *meaning* of the historical approach; and the teacher's self-assessment of expertise. To provide a clearer picture of the teacher's views, in a follow-up to this research, we also explored the *actual* use of history of physics by submitting to this sample of teachers a Google Form questionnaire.

The whole size of the sample was 156 units and slightly over 100 of them were physics teachers in secondary schools of the Turin and Cuneo provinces, in Nortwestern Italy. The statistical report issued yearly by the Italian Ministry of Education (MIUR) does not provide data about the actual number of physics teachers in Italy [16]. However, if we assume that the physics teachers versus a general population ratio is similar to that in the UK (i.e. about one physics teacher in England state schools per 10 000 inhabitants) [17], we can conclude that the secondary school physics teachers in the Turin and Cuneo provinces should amount to about 300 units. This makes our sample a decent starting point for reasoning on teachers' stances.

2.1. Usefulness of the historical approach

In the first part of the pencil-and-paper questionnaire, the teachers were asked to rate their attitudes toward the statement 'It is helpful to bring a historical approach to normal disciplinary teaching …' on the five-point scale. The alternatives offered were: (1) '… to show the technological evolution of instrumentation' and (2) '… to highlight the relationship between

physical intuition and the development of instrumentation'. Both alternatives were intentionally focused on instruments because we are especially interested in studying the educational power of the collections of physics instrument of historical-scientific interest preserved by the schools where the teachers are currently working [18, 19]. Most of the teachers were in agreement both with the 1st alternative (mean = 4.06; SD = 0.81) and the second one (mean = 4.04; SD = 0.81).

To the teachers, a third, open, alternative was also offered: 'Other (please elaborate)'. The analysis of the open answers provided by some teachers show reasons that are in at least partial agreement with the previous two alternatives. These answers are especially interesting since they are not constricted within the boundaries of the above alternatives. According to a large majority of teachers who filled out this field, it is helpful using the historical approach to contextualize scientific discoveries and developments (42 answers can be grouped in this class). A lessical analysis of words used in the open alternatives further enriches this picture; we find indeed the recurring presence of words like 'evolution', 'progress' and 'development'. We find also words like 'contextualizing' and 'understanding', which are relevant to the meaning of the historical approach (see section 2.2).

The possible usefulness of the historical approach was also tested by asking the teachers, on the five-point scale if they agreed or not with the—negative—statement that 'It is not helpful to bring a historical approach to normal disciplinary teaching …'. In this case, the alternatives offered were: (1) '… because of my lack of historical expertise'; (2) '… because I do not think it has value'; (3) '… because it would take too much time'; and (4) '… because some of the reasons given in the past are complex and contorted, risking complicating the understanding of the phenomena'. Most of the teachers who showed an agreement with the former question, answered also to this part of the questionnaire. Coherently with the preceding question, they largely disagreed with all the alternatives. By far, the single factor with which there was the greatest disagreement was the one concerning the lack of intrinsic value of the historical approach (mean = 1.52; SD = 0.74) (figure 1).

Overall, therefore, the vast majority of surveyed teachers think that the historical approach has merit as a physics education tool to provide a context for the physics subjects and to change the collections of scientific instruments from boring dust-catchers to lively and engaging tools of education [13]. Also, the majority of teachers believe that issues such as the complexity of actual history, the lack of historical expertise of teachers or the lack of time do not cancel out the benefits of the historical approach.

2.2. Meaning of the historical approach

By means of the second part of the pencil-and-paper questionnaire, we attempted to explore the teachers' idea of the historical approach. We submitted, therefore, the sentence 'Historical approach means …', to be completed with a number of possible alternatives: (1) '… providing bio-bibliographical infos on the scientists of the past'; (2) '… discussing the historical period in which the scientist worked'; (3) '… submitting original material in which the scientist presents his own thought'; (4) '… presenting the topics according to their conceptual development (e.g. how the concept of electric charge or the concept of heat have evolved)'.

On this issue, a marked difference of popularity emerged. For most of the physics teachers, the 'historical approach' means presenting the physics topics according to their conceptual development (mean = 4.21; SD = 0.79). Secondly and thirdly, the historical approach meant discussing the historical period in which the scientist worked (mean = 3.76; SD = 0.85) or submitting original material to the students (mean = 3.38); SD = 1.01). Among the alternatives offered, the least popular is the one where historical approach means providing bio-bibliographical info on the scientists of the past (mean = 2.85; SD = 1.05) (figure 2). The two most popular alternatives, therefore, make reference to the evolution of concepts and the historical context, in agreement with the lessical analysis of the previous item, showing the recurrence of words like 'contextualizing' and 'understanding'.

As is well known, school and university physics textbooks often include 'a bit of history', either in an introductory chapter or, more often, in scattered references and biographical sketches. This survey shows, however, that this is not

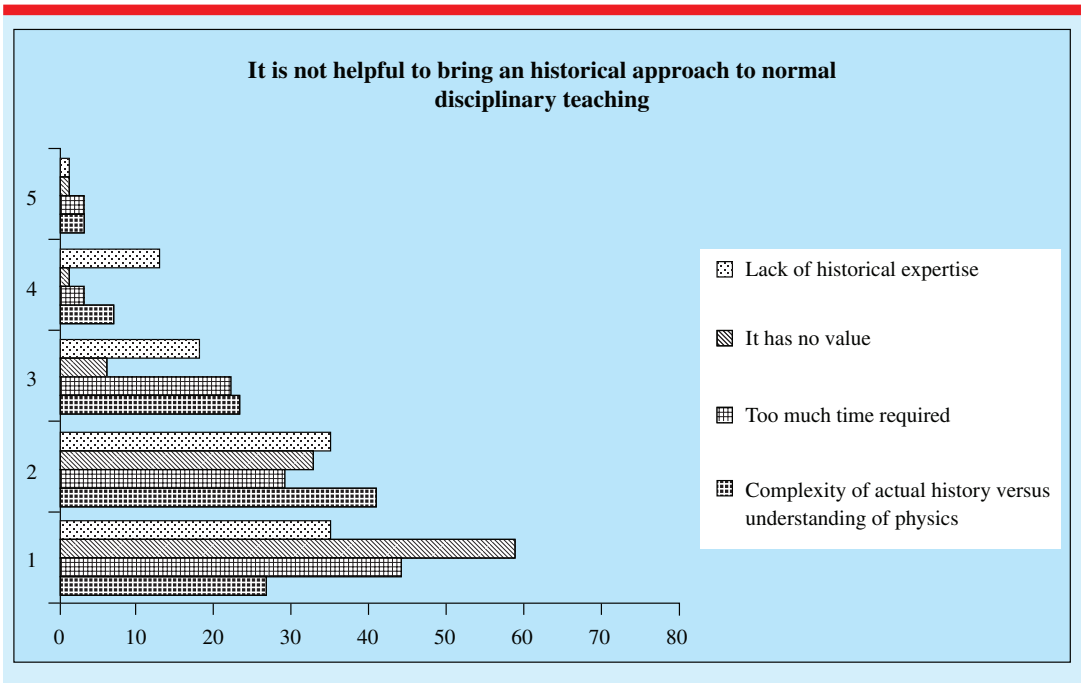

Figure 1. The majority of teachers believe that issues such as the complexity of actual history, the lack of historical expertise of teachers or the lack of time do not cancel the benefits of the historical approach.

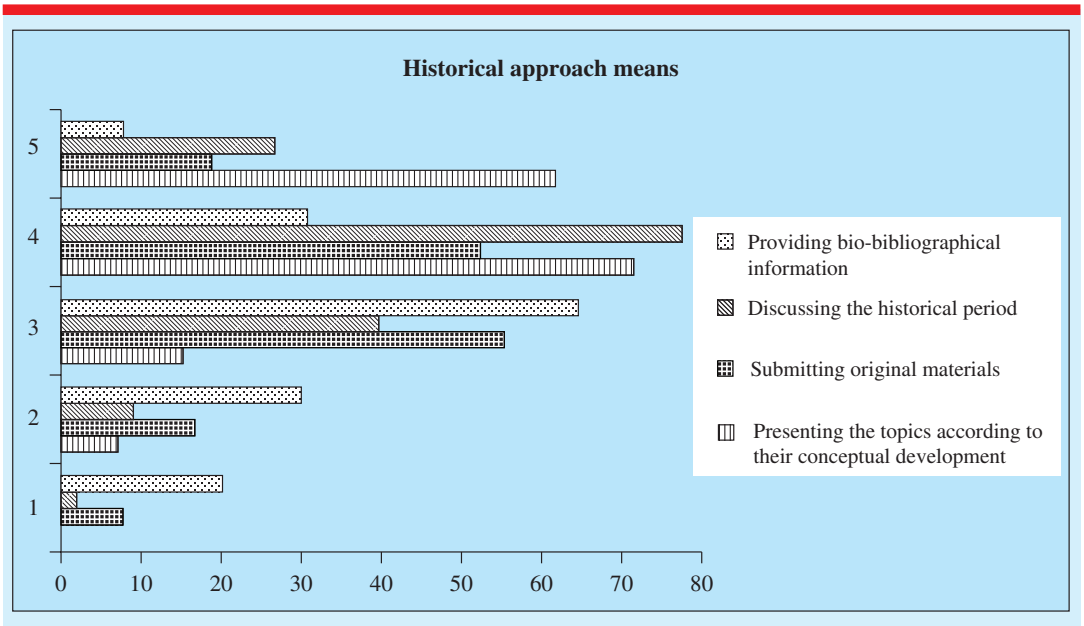

Figure 2. The historical approach has more to do with the evolution of concepts and the historical context than with the typical textbooks biographical narratives.

what the historical approach is supposed to be. According to the surveyed teachers, the history of physics in a didactic setting is not primarily a matter of biographical information or medallions but, rather, has to do with the manner in which the physics concepts developed and with the historical context and the framework within which the discoveries were made.

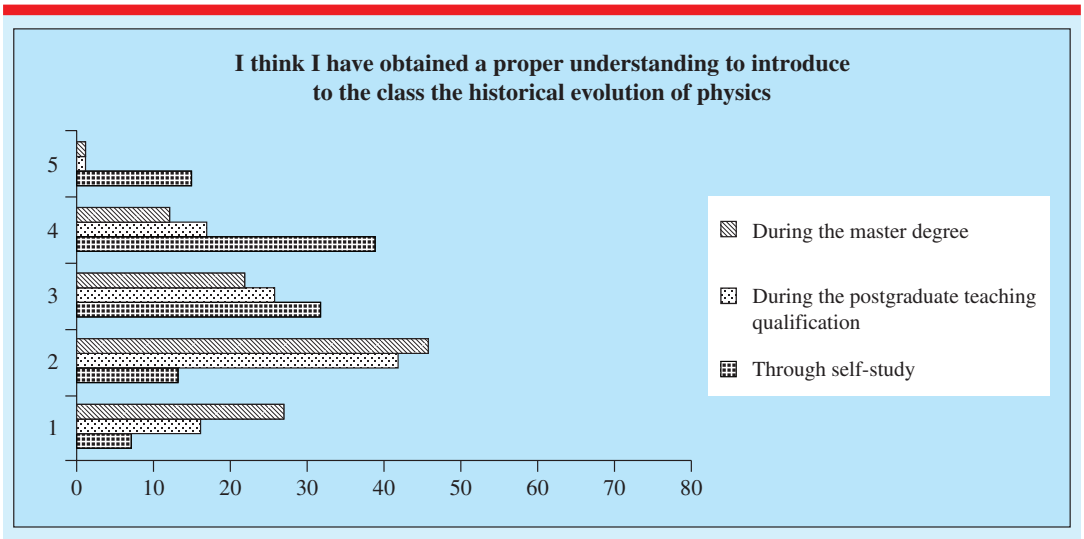

Figure 3. Most of the teachers think they have not received a proper preparation in history of physics during their masters degree years and also during postgraduate teaching qualification courses.

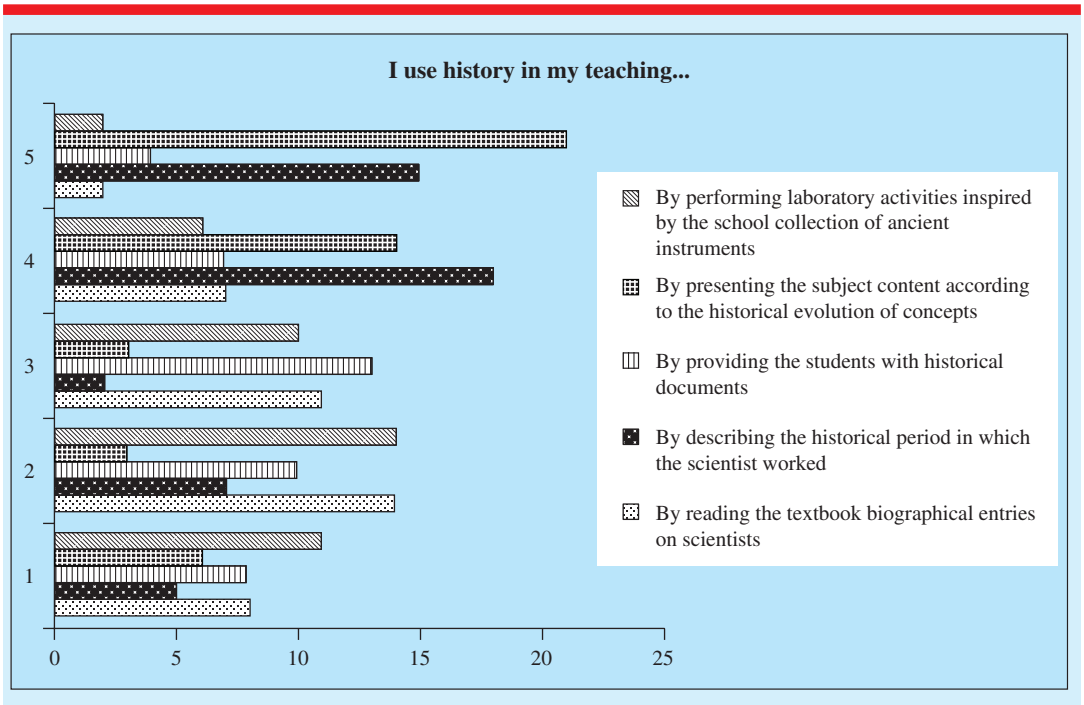

Figure 4. Only a few teachers provide the students with historical documents or perform laboratory activities inspired by the school collection of ancient instruments.

2.3. Teachers' self-assessment of expertise

Finally, the pencil-and-paper questionnaire addressed the teachers' self-evaluation of their skills by asking, on the five-point scale, their level of agreement with a number of statements concerning their expertise on the history of physics and their level of confidence on using the history of physics as a tool for physics education (figure 3). Although most of this sample of teachers were confident that the preparation they had

obtained by self-study research was adequate (mean = 3.40; SD = 1.08), most of them felt that they had not received an adequate preparation in the history of physics for educational purposes during their undergraduate years (mean = 2.20; SD = 0.97) and postgraduate years (mean = 2.46; SD = 0.98).

Three further questions explored the opinion of teachers over the current undergraduate and postgraduate curricula. In agreement with the above results, the teachers thought that a proper understanding to introduce to the class the historical evolution of physics should be achieved during the masters degree (mean = 3.94; SD = 0.91) and *a fortiori* during the postgraduate teaching qualification (mean = 4.20; SD = 0.75), rather than being left to the free initiative (mean = 2.43; SD = 1.02).

2.4. Do teachers actually use the history of physics?

The above inquiry had revealed a widespread positive attitude of teachers toward the educational power of the history of physics. But, do they actually use history during lessons and in which ways do they use history for physics education purposes? In the follow-up study, we explored these issues by submitting to the teachers a Google Form questionnaire asking them whether they use history in physics education, how often, and, if so, in which way. In order to assess this latest point, we provided the teachers with five answer options and asked them to rate them through a Likert scale (figure 4).

Only 50 teachers of the above sample filled out this web-based questionnaire. Unsurprisingly, most of those who answered reported using history (45 out of 50 teachers): 11 of them use history 'often' and 30 of them use history 'sometimes'. Interestingly, most of them use history by presenting the topics according to the historical evolution of concepts (mean = 3.85; SD = 1.38) and by introducing the historical period in the scientists had worked (mean = 3.63; SD = 1.34). Just as interesting are the facts that only a minority of these teachers pay attention to the biographical accounts of the textbooks (mean = 2.6; SD = 1.1) and that primary historiographical sources are usually neglected. If only a few are the teachers who offer the students original documents from the past (mean 2.73; SD = 1.23), even fewer are those who carry out laboratory experiments inspired by the collections of ancient instruments preserved by the schools (mean = 2.40; SD = 1.14) (figure 4).

3. Discussion

The overall pattern that emerges as a result of this survey is one of positive feelings of the teachers toward the historical approach in the physics education. Of course, some caution is in order in interpreting the results of this study because of the particular subset of teachers participating in the survey that makes this sample not representative of the general population of physics teachers.

According to the majority of teachers, it is useful to introduce history of physics in an educational setting. The few reservations expressed against its use in this domain focus more on the lack of historical expertise of the teachers and the intrinsic complexity of the actual history and less on the short time allotted to physics education in secondary school.

As for the meaning of the historical approach, for the surveyed teachers, the history of physics in a didactic setting is not primarily a matter of biographical sketches, as in many textbooks frequently it is but, rather, has to do with the development of the physics concepts and with the historical context and the framework within which the discoveries were made. As outlined in section 2.4, however, only rarely does the teacher make use of primary sources, like original books or papers, and even more rarely do they exploit local resources, e.g. the material collections of historical instruments preserved by the schools.

These last results should not come as a surprise given the teacher's self-assessment of expertise. The results within this area, showing important degrees of dissatisfaction as to the methodological preparation obtained during masters degrees or during postgraduate teaching qualifications, has important implications for educational policies.

On the whole, these preliminary results suggest that the teachers more active in the in-service training activities do not question the validity of the historical approach. However, a minority of them fear that factors like the lack of adequate preparation in the undergraduate years might compromise the outcome of this approach. To

avoid this condition, a concerted action both at the undergraduate and at the in-service level is in order. If during the masters degree years, a physics curriculum including history of physics modules providing example of case studies for educational purposes is recommended, at the in-service level the teachers would benefit of training seminars on the educational power of history including operational guidelines and recommendations for good practices. Experience gained so far at the University of Turin suggests that substantial improvement in teachers' attitude toward this issue can be obtained with rather straightforward partnerships based on the exploitation of the historical scientific collections of scientific instruments preserved by the schools [18, 19].

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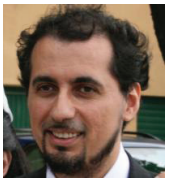

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