THE ROLE OF THE HISTORY OF SCIENCE IN PHYSICS EDUCATION, TEACHERS' VISION

Franjo Sokolić, Damir Rister and Ivica Luketin

ABSTRACT
The Croatian teachers' attitudes toward the role of the history of science in physics education are examined by a questionnaire. Although they had very few lessons in the history of science in their education, they are declaratively favourable to its introduction in education. They are much more reserved towards practical application in teaching because they are more inclined to problem solving.

KEYWORDS
History of science, physics education, misconception, teachers' attitudes

INTRODUCTION

The role of the history of science is essential in the curriculum of the future teachers of science, especially in a field such as physics, which is very abstract and demanding. It has been noticed that even at a very high level of education there still exist misconceptions concerning the most fundamental notions like force, energy, heat, etc.

In the normal physics curriculum there is not enough analysis of fundamental concepts. They are generally given without detailed analysis, as if they were self-evident. Unfortunately this is not generally the case, and even worse, the scientific notions are not identical to those used in everyday life under the same name, as is the case with the notion of heat.

In order to clarify the fundamental notions in physics we propose a workshop in the history of physics for physics teachers, considering that the historical context in which physical questions appeared may help to better understand the problems behind the notions themselves.

Concerning the introduction of the history of science in the physics curriculum, one may ask the most fundamental question: What is the principal aim of science education? The possible answers could be: to get sufficient technical abilities to know how to use modern technology, or to be able to use concepts which are necessary to cope with the problems of modern society. Although almost everybody would agree with the second statement, education is not organized in a way to answer this demand. The problem is that teaching is oriented finding solution to numerical problems and data memorization. There are very few instances of the critical analysis of fundamental problems. Students are taught how to solve typical problems which perfectly fit the given worldview (the dominant paradigm). Unfortunately, common problems are not of this type. This gives the impression that standard exercises solved in physics classes are completely detached from common sense. One way of coping with this problem is to introduce some historical aspects of the way in which concepts were introduced and elaborated. The difficult elaboration of most of the fundamental concepts shows that they are not self-evident and easy to manipulate. As an example we may cite almost two millennia long story of coping with the problem of the description of motion from Aristotle to Galileo and Newton. The other aspect of

the history of a given human activity, such as science, is that by this means, it acquires a more human dimension, instead of being a completely disincarnated stuff.

Before starting a workshop on this subject with physics teachers we wanted to know what exactly their attitudes with respect to these questions are. What do they think about the introduction of historical topics in physics classes? How to deal with historical items in science education?

With this aim in mind we prepared a questionnaire for physics teachers. The questions can be separated in several groups. The first one concerns their general attitude towards the history of science education in general education and then specifically in science education. Actually it has two different roles. In science education it should help understand the basic notions of the field. In general education it has to answer the question of how abstract ideas appear in the history of the civilization.

THE HISTORY OF PHYSICS AND PHYSICS EDUCATION

Among many facets the school has, we highlight its role in acculturation. According to A. Whitehead, (1929) culture is a metaphor for the activity of thought, empathy for beauty and human feelings. He argues against didactic introduction of school science as end body of knowledge outstretched from context of creation. “In training a child to activity of thought, above all things we must be aware of what I will call “inert ideas” - ideas that are merely received into the mind without being utilized, or tested, or thrown into fresh combination. Education with inert ideas is not only useless: it is above all things harmful – "Corruptio optimi, pessima"”.

Although the aim of physics is, as the historian of physics A. French (1998) formulated, to “relate our knowledge of phenomena to a minimal number of general principles”, physics teaching cannot be a tour through logical structured building of physics content cryptically expressed in the language of mathematics. Physics education researches to inform physics teacher at all levels how to avoid learning of physics as collection of disconnected, inert ideas. We shall mention only some of those concerning the role of the history of physics in physics education.

R. Stuewer (1998) describes several examples in physics history which illustrate how difficult, illogical and complex can the attempt of inventing new physics notions be. He advocates not only to reduce the history of physics to interesting ”vignettes and anecdotes” sprinkled through textbooks of some physics courses, but to ”focus on intellectual, social and political contexts in which principles, laws and concepts were discovered ”.

In a similar manner, R. Krsnik (2005) situated the historical models in physics teaching. This kind of models, partially overlapped with contemporary scientific models, increase the motivation of pupils, help understand and change naive pupils' conceptions (ontogenesis recapitulates phylogenies), help to demystify the prejudice of linear, smooth growth of physics knowledge, foster the importance of social basis of science. Krsnik devised gymnasium physics curriculum in Croatia based on introduction of every new concept and law in a problem situation, mainly experimental but often mimicking conflicts happening in physics history. Although ranked high as excellent curriculum improvement, it was not accepted more widely, not only because of the intellectual burden imposed on teachers, but also for time constraints.

Not quite appropriate in this context describing physics education and history of physics, we shall mention A. Arons (1997) question what physics education community have learned from past experience, namely from the ”failure of past curriculum efforts”. The history of past curriculum reforms informs us that the main reasons for weak dissemination have been bad logistics and teachers not trained for interactive, vivid teaching promoting creativity and the habits of critical thinking.

A radically different stance is F. Herrmann’s call for the reprocessing of physics curricula. He blames our intellectual inertia to maintain somewhat fossil appearance of physics teaching, which force every

“individual student to follow, often up to the details, the same tortuous way as the history of science as a whole” (Black and Herrmann, 1996).

The more recent research in physics education is rarely concerned with the role the history of physics should have in physics teaching and learning. For example, Redish and McDermott (1999), in their seminal overview of research in physics education, mentioned the word history twice, and even then in connection to the new ”bride”- cognitive revolution. C. Wieman and K. Perkins (2005), in a recent call to transform physics education underline the well-known perspective prevailing among laymen – “learning of physics is information memorization and problem-solving recipes that apply to highly specific situations”. They propose the remediation of physics curriculum not even mentioning the history of physics. A seemingly wider context had been established by R. Duit (2007) in his definition of physics education as an interdisciplinary endeavour. He recognizes the philosophy and history of science as components in this scholar field.

It is not clear what value the historical and cultural approach would have in the future physics curricula. Cognitive sciences, new technologies and computational science are the heroes of modern times.

SAMPLE AND METHODOLOGY

Research was conducted using a questionnaire for the teachers. The survey took place in the spring of 2008 during a Seminar for the physics teachers from the entire country (Croatia). The seminar is a part of teachers' in-service training. The Seminar was attended by around 180 elementary and secondary school physics teachers (near 10% of whole physics teacher population in Croatia). All of them received the questionnaire, and they were supposed to fill it in and leave it at a specified place. The questionnaire was anonymous.

The attendance at the seminar was not obligatory for the teachers and because of that the sample can not be considered as representative for the population of physics teachers in Croatia since it can be expected that the participants belong to the group of more motivated teachers. In the same manner, only the more motivated participants of the seminar filled in the questionnaire.

In total, 128 teachers filled in the questionnaire (71 women, 52 men, 5 did not answer the question). Around one half of the participants of the survey work as elementary school physics teachers (grades 7-8, 13-15 year old pupils). The other half work in the secondary school (grades 1-4, 15-19 year old students). The average teacher's age in the survey is 48 years (median), and the average time spent in teacher service is 20 years. In Croatia, the population of physics teachers is rather old in average – older than in most other subjects and the sample shows this general tendency.

RESULTS AND DISCUSSION

Because the teachers of physics are the most important factor influencing the spirit of teaching physics in class, we investigated attitudes of primary and secondary school teachers.

We can begin with teachers’ personal experience. For as many as 33% of teachers their knowledge of the history of physics didn’t help them on their own way to construct physical concepts. (Figure 1.)

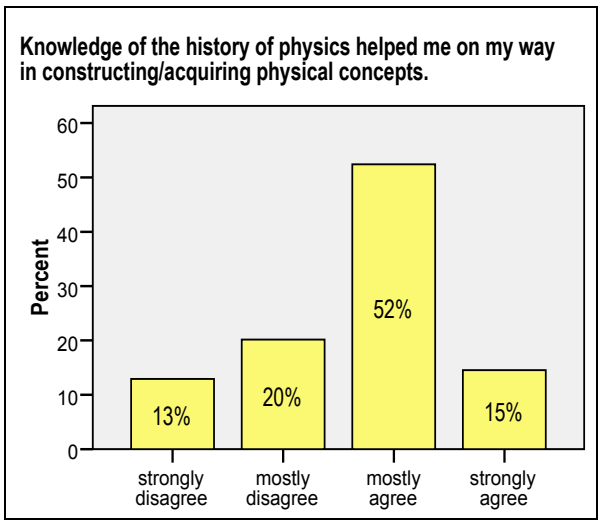


Figure 1. Teachers' response – "*Knowledge of the history of physics helped me on my way in constructing/acquiring physical concepts*"

More teachers (44%, Fig.2a.) admit that they are satisfied with the abundance of topics from the history of physics during the university study of physics (typically one 2-hour semester course, occasionally some topics throughout general physics) and 38% (Fig.2b.) don't think that during the (university) study of physics more attention should be paid to the history of physics.

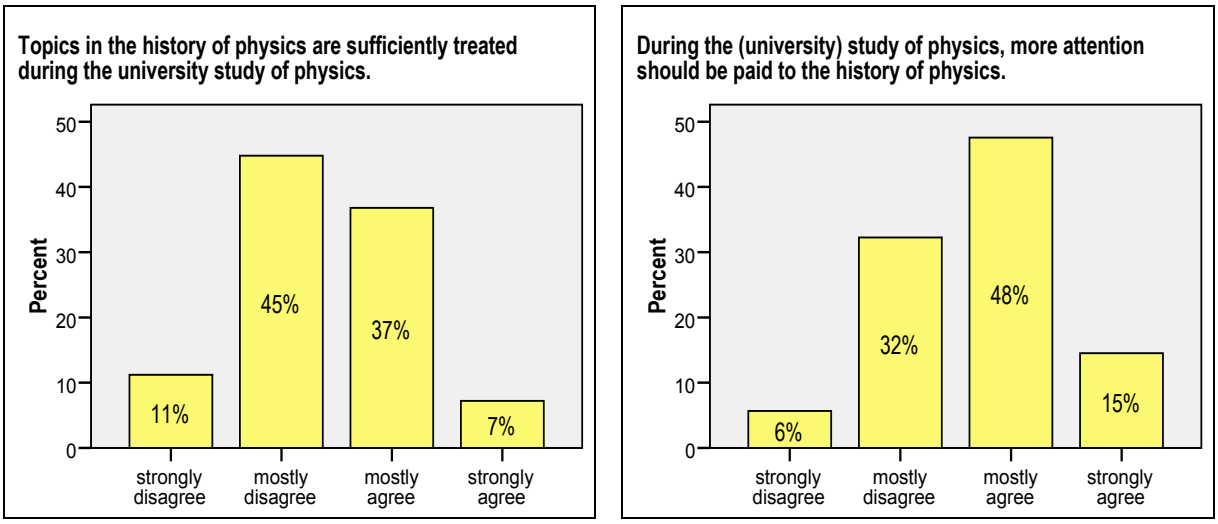
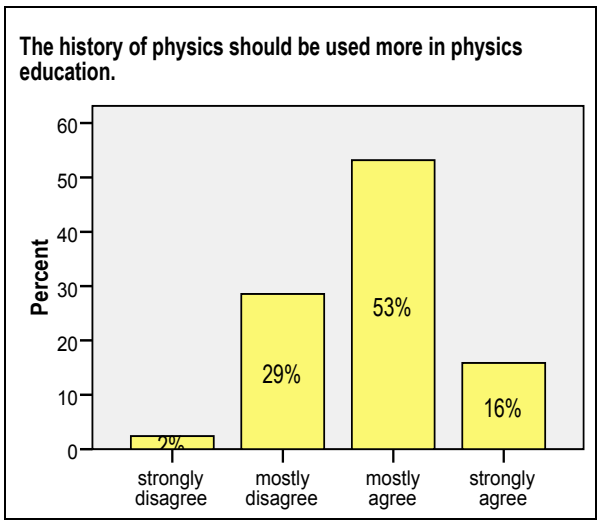


Figure 2a. Teachers' response – "*Topics in the history of physics are sufficiently treated during the university study of physics.*" and 2b. "*During the (university) study of physics, more attention should be paid to the history of physics*."

Also, approximately the same fraction of teachers (31%, Fig.3a.) would not pay more attention to the history of physics in the preparatory physics didactics course during the university study of prospective physics teachers. How distinctive are their conceptions of physics and history is evident if we considered their positive responses to the statement "If I had been interested in history, I wouldn't have studied physics" (27%, Fig.3b.).



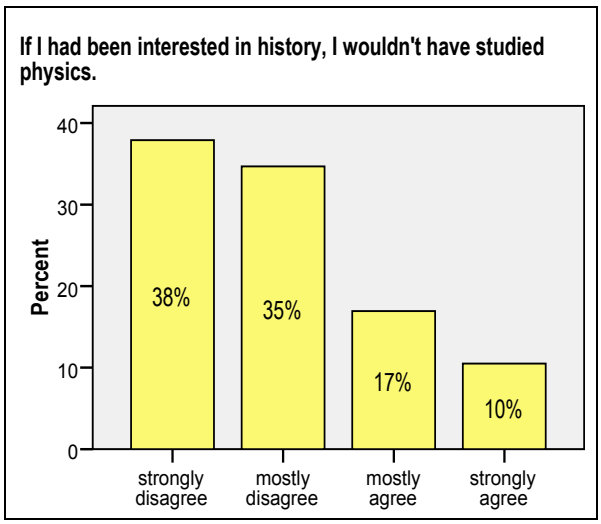
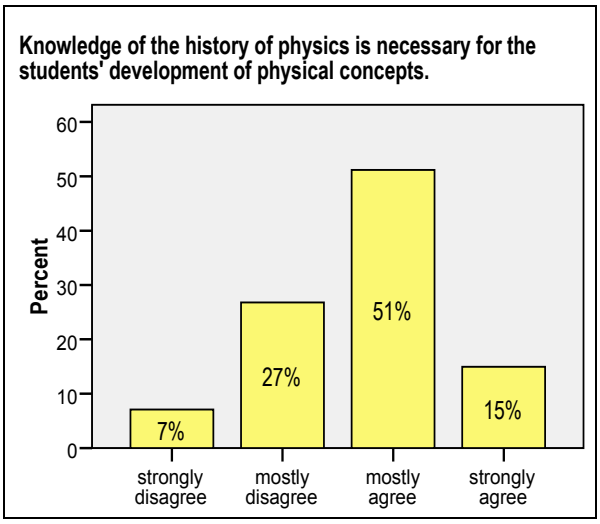


Figure 3a. Teachers' response – "*The history of physics should be used more in physics education.*" and 3b. "*If I had been interested in history, I wouldn't have studied physics.*"

This fraction is in good agreement with the percentage of teachers who think:

- that for acquiring physics concepts is not necessary knowledge of the history of physics (34%, Fig.4a.)
- that pupils are not interested in the history of physics (32%, Fig.4b.)



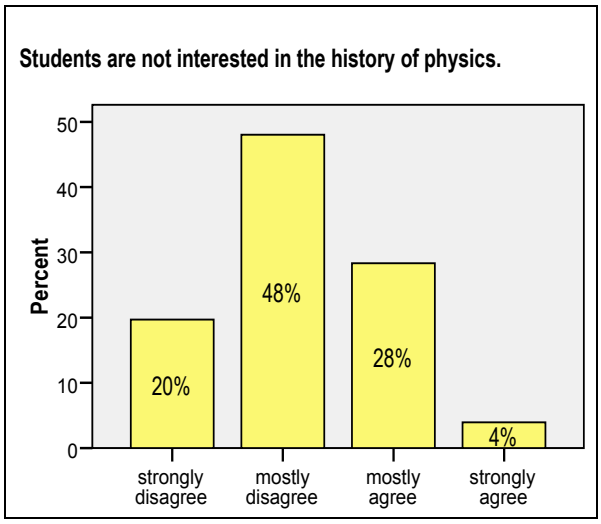


Figure 4a. Teachers' response – "*Knowledge of the history of physics is necessary for the students' development of physical concepts.*" and 4b. "*Students are not interested in the history of physics.*"

- that it is not necessary to include the history of physics in the class (24%) (Figure 9.)
- that it is more useful for the pupils to solve problems than to retell events from the history of physics (39%) (Figure 5a.)
- that the knowledge of the physical theories which were rejected in the past creates an even bigger confusion in the minds of the students (37%) (Figure 5b.)

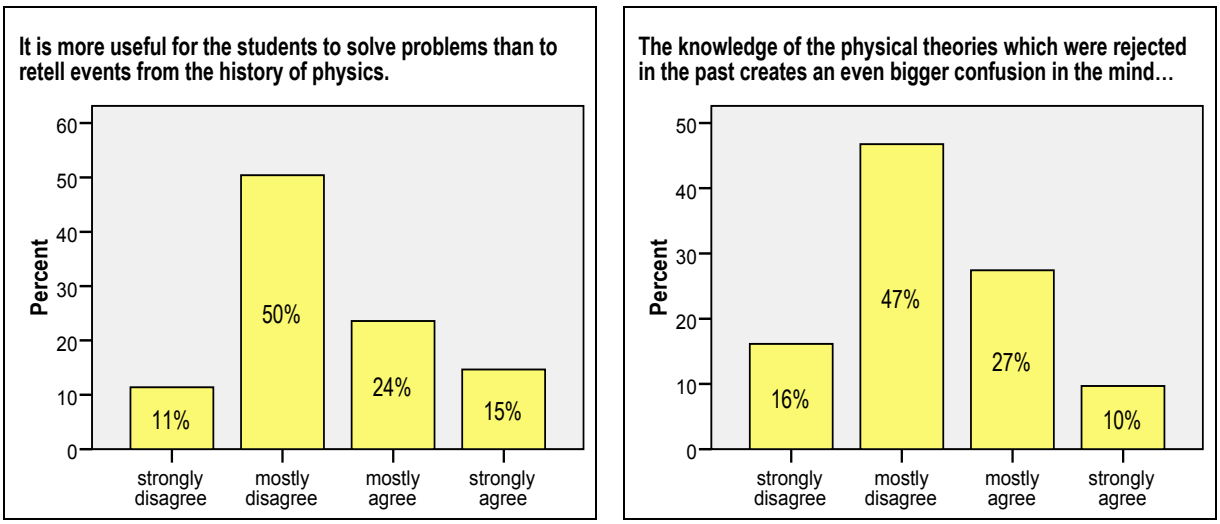


Figure 5a. Teachers' response – "*It is more useful for the students to solve problems than to retell events from the history of physics.*" and 5b. "*The knowledge of the physical theories which were rejected in the past creates an even bigger confusion in the minds of the students.*"

- that pupils should be taught the latest knowledge, not outdated and wrong theories (45%). (Figure 6.)

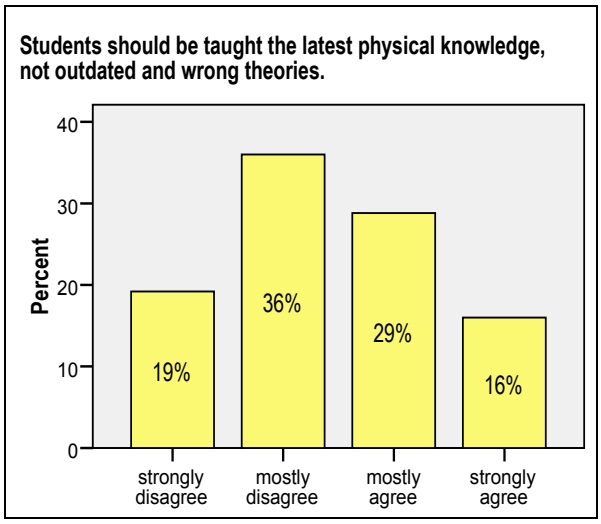


Figure 6. Teachers' response – "*Students should be taught the latest physical knowledge, not outdated and wrong theories.*"

This last assertion is accepted by much more than one third of teachers which we detected as those badly prepared and not ready to convey the cultural and critical role of the history of physics in physics teaching. Partially, the reason for this is the negative connotation subsumed in words "outdated" and "wrong". A more neutral attribute "replaced" describing old theories would be appropriate to highlight our constructivist position, hopefully attracting more teachers.

The situation in class seemed not to be too bad especially in light of a huge percentage (90%) of teachers accepting that the history of physics is very attractive. (Figure 7.)

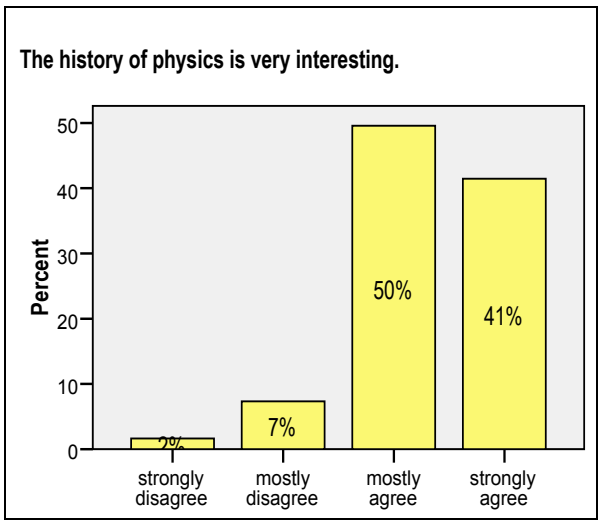


Figure 7. Teachers' response – "*The history of physics is very interesting.*"

It seems that two thirds of surveyed teachers accept the important role the history of physics plays in the formation of science literacy with the stress on critical thinking. But, we are very troubled with the impressive 91% of teachers who consider that there is not enough time to include the history of physics in the class (Figure 8).

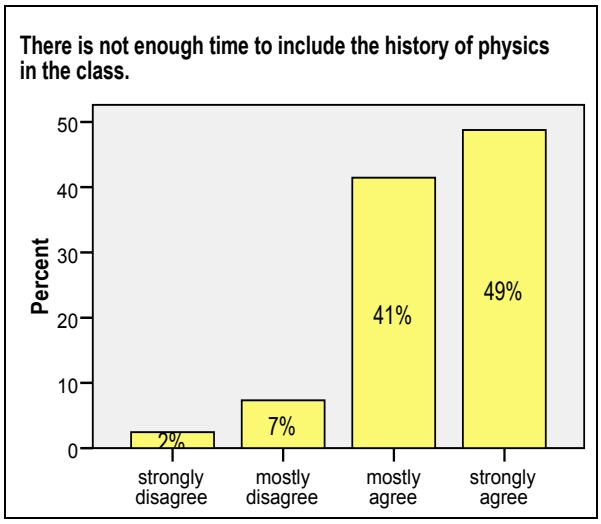


Figure 8. Teachers' response – "*There is not enough time to include the history of physics in the class.*"

On declarative level, only little less than this fraction of teachers support the inclusion of the history of physics in physics teaching (77%), but we may make the hypothesis that they omit to do so because of their duty to cover the physics content in the manner expected by the dominant positivistic habit (Figure 9).

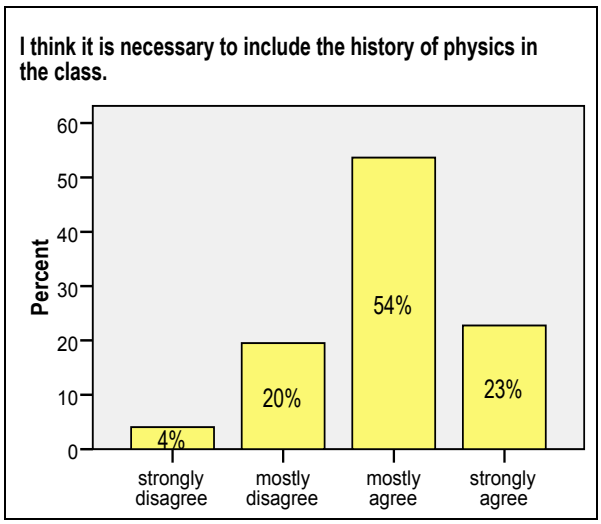


Figure 9. Teachers' response – "*I think it is necessary to include the history of physics in the class.*"

Positivists in educational settings put more value on informing the pupils about the end products of physics. It will help them to solve problems and qualify on university entrance exams. Unfortunately, even teachers who verbally confirm the educational relevance of the history of physics, practically don't accept our claim that physics learned only in developmental continuum ensures coherent understanding and the use of physics knowledge.

CONCLUSION

The attitude of physics teachers toward the introduction of the history of science into the physics curriculum was examined through a questionnaire. The general attitude may be considered as globally positive, as only one quarter expressed the opinion that the history of science is not needed in science education. This may be considered as an encouraging result, knowing that these teachers had only one or no courses in the history of science. When the questions were about the practical implementation of historical subjects in the curriculum, most of the teachers expressed their reluctance to do it, with the excuse that too much time is needed for it. It may be concluded that declaratively they are for the history of science in classes but in reality they are pragmatic and prefer classical numerical problem solving. This is also the standard way how their knowledge is tested. It is much more difficult to test how profound their conceptual understanding of physics is. The next step would be to have a workshop with the teachers on the history of science, and to test afterwards if their attitude changes. The most important final test of the utility of the history of science as the motivator for teachers would be to compare the attitude and the achievement of pupils who are taught by those teachers who accept the important role of the history of science versus pupils having teachers with the opposite ideas. We expect that teachers with the knowledge in the field of the history of science would be much better educators, having a profound feeling for pupils' problems and especially their misconceptions.

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Franjo Sokolić
Faculty of Science
University of Split
Teslina 12, 21000 Split
Croatia
Email: sokolic@pmfst.hr

Damir Rister
Centre for Educational Research and Development
Institute for Social Research, Zagreb
Amruševa 11, 10000 Zagreb
Croatia
Email: rister@idi.hr

Ivica Luketin
Faculty of Science
University of Split
Teslina 12, 21000 Split
Croatia
Email: luketin@pmfst.hr