

Qualitative analysis of high school and university textbooks on thermodynamics and statistical physics

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Abstract. In this research, focused on selected topics on thermodynamics and statistical physics in secondary and higher education, we aim to find out how well the basic concepts are defined in high school and university literature. Critical analysis of available textbooks and teaching materials was carried out. By examining the accessible Czech and foreign language textbooks, as well as multimedia sources (web pages, computer simulations etc.), associated with teaching thermodynamics and statistical physics at both levels, we probe the quality of the learning sources. Based on this research, new educational materials will be prepared and piloted in secondary schools and universities.

Introduction

In the recent years a rather disconcerting trend can be observed in the decline of the knowledge of high school physics students as well as those of the first years of university studies. This decline is due to many factors, one is the reduction of physics curriculum, second is due to insufficient mathematical preparation. Especially, thermodynamics and molecular physics is students' weak point [1,2]. This led us to investigate the accessible Czech and foreign language (mainly English and Russian) textbooks on thermodynamics and statistical physics as well as multimedia resources (web pages, video lectures etc.) and carry out their critical analysis. Based on this analysis, we propose new ways and approach of explaining basic thermodynamic and statistical concepts in order to obtain clearer picture between the two disciplines.

Theoretical framework and research questions

The scope of the curriculum of thermodynamics and molecular physics does not correspond to modern concept of physics. High school thermodynamics is presented as the science of ideal gas and heat engines [1]. This clearly narrows the generality of thermodynamics. In today's perspective of modern physics, students should learn the formal structure of thermodynamics (to the extent available) which teachers should then document with a range of examples both from everyday life and from physics itself. Students should also gain a basic understanding of the second law of thermodynamics, which, however, is suppressed by the science of heat engines [3,4]. As far as molecular physics is concerned, its basic assumptions are not clearly stated. The acquired knowledge of molecular physics is not sufficiently connected with thermodynamics. The curriculum of high school thermodynamics and molecular physics is very different from that at university. In high school thermodynamics and molecular physics textbooks, the curriculum is mixed together without explicitly mentioning it. This causes student confusion while learning the subject. In this research, we focus on the high school and university textbooks on thermodynamics and molecular physics (statistical physics) and present their critical analysis. In relation to the reviewed textbooks, we ask ourselves mainly these questions:

1. Is the curriculum of thermodynamics and molecular physics inter-connected so that the mutual connections stand out?
2. Do the textbooks show the generality of thermodynamic laws and its methods on appropriate examples?

3. Are the basic concepts of thermodynamics correctly defined? Are these concepts appropriately explained in molecular physics?

Methods and findings

Qualitative content analysis is used in order to answer the questions given above. Especially focusing on the point 3 in the list, we compare the definitions of the basic concepts of thermodynamics and molecular physics on high school and university level education. Among the basic concepts of thermodynamics, we included the very definition of the term thermodynamics, as well as thermodynamic system, thermodynamic equilibrium, temperature, laws of thermodynamics, heat and work. Speaking of molecular physics, we focus mainly on the interpretation of temperature and ideal gas law.

Currently, the critical analysis of the textbooks is finished while the analysis of multimedia resources is still ongoing with the fact that at the time of the conference the conclusions will be finalized and the participants can familiarize themselves with them.

Conclusion

At present, it is possible to state on the basis of literature review that the state of Czech secondary school textbooks of thermodynamics and molecular physics, and thus the teaching of these, is declining. Textbooks are outdated, there is no integration of physics with other natural sciences, e.g. chemistry, biology. Thermodynamics is not presented as a general science, although the definitions of the basic concepts are introduced relatively well, however, their importance is not pointed out and there is a lack of connection with other concepts. Thermodynamics and molecular physics are not divided into two separate parts, as in the case of university courses, the curriculum is mixed without the authors drawing attention to it, so that the connection between these fields is lost. Based on this literature review, new teaching materials (worksheets for teachers and students) will be created. Pilotage of these materials will be then carried out on high schools and universities.

References

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