RAISING QUALITY OF PHYSICS EDUCATION: CONTRIBUTION OF JBSE OVER THE PAST ISSUES

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I have worked more than thirty years in physics education (as some of the readers of this journal), many years as a secondary school physics teacher in various curricula (as some of the readers), and more than 20 years at university doing research and preparing future physics teachers (as some of readers). I am also the author of a physics textbook for secondary education, and now I am working on a new one. Naturally, I would like to have the new textbook, like my other outputs, based on the current state of knowledge and well-developed and well-applied theories behind physics education. And here is the seed of the question - how does our journal contribute to raising the quality of our outputs – in my case, increasing the quality of physics education? I first look at the goals of physics education. Here, I use the most straightforward taxonomy of goals presented in (Demkanin 2013): goals related to attitudes of society to science, goals related to methods of science, and goals related to particular knowledge. The last one I split into two sub-goals – knowledge selected to develop methods and attitudes and knowledge selected to raise the quality of living and general scientific culture. Of course, the goals we can reach by means – by the methods of education – methods of teaching and learning. So, let's look at a few previous issues of JBSE and at the contributions having the potential to raise the quality of physics education. I have mentioned only some of the contributions I will probably use in the next few years. I tried to focus on physics education, not explicit chemistry or biology education, even if some of such articles could be fully relevant to my work.

Goals Related to Attitudes of Society to Science

Lamanauskas (2022) emphasised that the natural science literacy of society is insufficient, and its relevance significantly increased in the last decades. In the previous issues of JBSE, we clearly see the importance of environmental education – influencing public opinion about climate change and environmental issues. Lavonen (2022), discussing climate education, highlighted the need for well-educated physics teachers and a new paradigm for preparing physics teachers. Aberšek (2021) discussed the gap between scientists, pseudo-scientists, influencers and politicians, and this gap illustrates the topic of global warming and other ecological issues. Agostinis-Sobrino et al. (2021) discussed health education and lifestyle behaviour, which also could be relevant to changing attitudes to physics education. An interesting term, The Happy Planet Index, is discussed in (Janoušková & Bílek, 2022). Analysis of school textbooks on Physics and other natural science subjects is offered by Revák et al. (2023), who analysed energy awareness education in these books.

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Goals Related to Methods of Science

Wider and Wider (2023) examined students' problem-solving skills and related metacognitive abilities. Taking dimensions such as monitoring, regulation, and evaluation (metacognitive), understanding the problem, devising a plan, carrying about the plan, and looking back, they looked deeply at students' problem-solving skills. As formal education, physics education is rooted in natural science education in primary schools. Lamanauskas (2022) highlighted the need to solve educational problems relevant to primary school pupils, forming their life values. In his research, he found that discussions are not encouraged enough in Lithuania at the level of primary schools. Much more popular are practical activities and demonstrations. Improving science process skills of students with mild intellectual disabilities is examined by Şenel Çoruhlu et al. (2023).

Goals Related to Knowledge Selected for the Development of Methods and Attitudes

I am sure we have some articles dealing with physics knowledge selected for school courses to develop science process skills and attitudes to science, but I did not find anything explicit in the past issues. One more, this does not mean that we do not have such articles. Some readers can argue that everything we teach is developing methods of science and attitudes.

Goals Related to Knowledge Selected to Raise the Quality of Living and General Scientific Culture

The concept of inertia, an essential topic of mechanics, with some critical notes from the history of this topic, is discussed by Bussotti (2021). Alternative conceptions of students in Newtonian mechanics are examined by Bahtaji (2023). Learning heat and temperature concepts by pupils at primary schools are discussed by Tseng et al. (2023).

Teaching Physics

In the context of climate education, Lavonen (2022) highlighted the relevance of project-based teaching methods, guiding students to ask relevant questions related to the complex phenomenon, critically search for information, participatory approaches, and affect-driven approaches. Alp and Coskun Onan (2023) analysed the possibilities for using comics to constitute climate change awareness in 5th grade. Aberšek (2021) highlighted, in the context of science versus pseudo-science, the development of critical thinking and strategic separation of truth (ideas based on science) from potential lies (alternative ideas contrary to scientific ideas, myths). The development of the physics module applying categories such as personal interest, sense-making, and effort is discussed by Sulaiman et al. (2023). The difference between end-of-chapter problems and inquiry activities used as homework was investigated by Simić et al. (2023), who found that simulation-based and video-based homework contributes to the improvement of conceptual understanding in mechanics. The role of multimedia (simulations, animations, videos, models) in teaching university students black body radiation, photoelectric effect and other quantum physics topics is discussed by Nyirahabimana et al. (2023). Interesting factors related to the social responsibility of scientists and engineers, as viewed by pre-service physics teachers, are analysed by Zhang (2023). The typology of questions used by science teachers is examined by Saka and Inaltekin (2023).

Learning Physics

Illustrated on science teacher education, Feser (2021) discusses the topic related to future science teacher learning, the topic of belonging to science. How do physics teachers feel as an integral part of the physics community? How do physics researchers feel physics teachers belong to the physics community? Secondary school students' perception of the science learning environment, especially metacognition and self-efficacy, is analysed by Kim and Alghamdi (2023). A construal level theory, which includes the term psychological distance, illustrates environmental issues Aberšek (2022). Toulmin's argument pattern and its impact on the learning of lower secondary school pupils in the context of the solar system, force and motion, and systems in the human body were analysed by Acar and Azakli (2023). They report that using this argument pattern raised pupils' metacognition and logical thinking. The effect of a particular combination of home and classroom activities encouraging students

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to take more responsibility for their learning is examined in the context of direct electric current topics Radulović et al. (2023). Physics teachers' learning how to use research papers to creatively develop teaching sequences of a particular quality (based on the information from the research papers) was studied by (Park, Yoon, Lee, 2023). Our journal, as well as general physics education, includes the education of students with mild intellectual disabilities. Improving their science process skills was examined by Şenel Çoruhlu et al. (2023).

Contribution to the Raising Quality of Future Physics Education

Empirical research well set to a theoretical background, without doubt, is much better than empirical research based only on the intuition of a person with limited experience. Even if I have more than 30 years of experience with secondary school students and university students – students in pre-service studies, in-service courses and students of hard science, I still feel a need to cultivate my theoretical background. One type of activity related to this need is looking at JBSE articles, letting them go through the filter of my previous experiences and theoretical knowledge, allowing them to resonate, interfere, constructively or destructively. It is quite a pleasant experience to identify a myth I have used as a truth for years. Similarly, it is a pleasant experience to see that some groups of people thousands of kilometres from my hometown, Bratislava, think likewise and believe in the same principles and tenets of physics education as I use in my research and teaching practice.

Physics, Physics Education, and the Theory of Physics Education are often considered quite old science disciplines. Some say that the roots are in Newton's Principia (Newton's laws are probably in every physics textbook), some say that even Archimedes was important in the development of Physics (Archimedes' principle is perhaps in every physics textbook), methods of education applied to teaching Newton's laws and Archimedes principle are probably in every course on didactics of physics. Where to go in raising the quality of physics education? Better selection of physics topics taught in schools – to cultivate attitudes of society, better use of new digital technologies – to cultivate the abilities to use methods of science? Let me be less abstract – let's look at concrete material – water/ice and graph its density versus temperature (in stable states), Figure 1, and detail in Figure 2.

Figure 1
Density-Temperature Graph for Illustration of Context

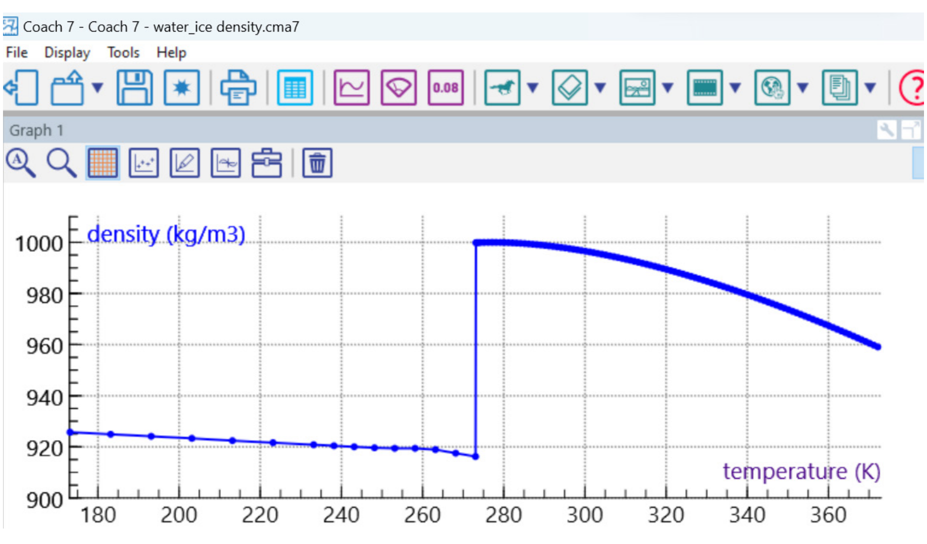

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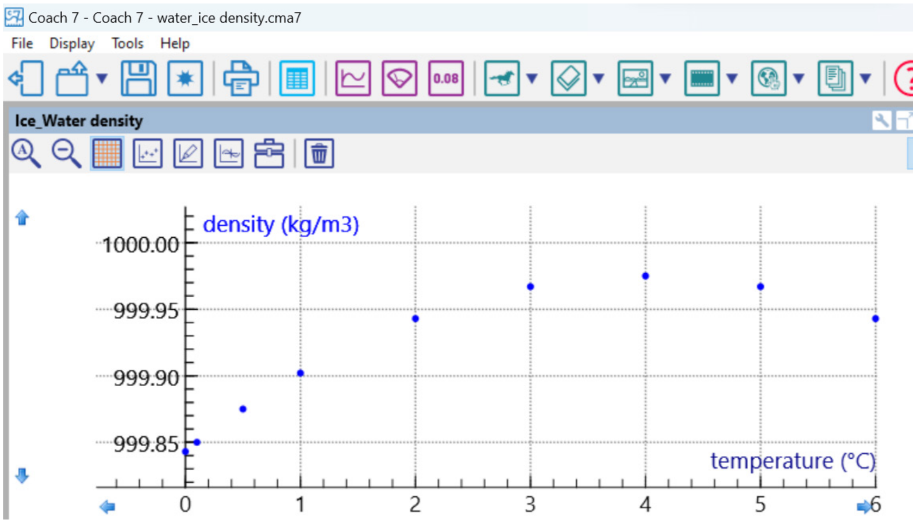
Figure 2
Interesting Detail on the Density-Temperature Graph, Note the Unit of Temperature Used



What to teach and how to teach about water and ice? How can we raise the quality of using contexts related to water and ice in physics education? And how to teach? And how do our students learn?

One way that naturally emerged in the last decades could be based on the application of new knowledge in neurosciences, in the science of mind-brain-education. Similarly, as physics education was influenced by researchers such as Piaget, Maslow, and Bruner in the second half of the 20th century, nowadays, we can try to incorporate into our efforts the results of research of groups focusing on possibilities of applying knowledge based on new opportunities of brain scanning, artificial intelligence. Besides articles published in JBSE, I often look at some books and can recommend one here. Tokuhama-Espinosa (2021), in her book *Bringing the Neuroscience of Learning to Online Teaching*, brings many ideas applicable to the theoretical backgrounds of our articles related to improving physics education in the near future.

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