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Review of the Ph.D. thesis of Daniel Dziob

In his thesis, Daniel seeks answers to the most fundamental and relevant questions related to physics education, such as "How to increase the motivation of students tle learn physics?" and "How does the subject relate to examples in real life and to our lives in general?". Motivation and a keen sense for insightful delivery of the subject are key pillars of our success in teaching future generations about physics, and it is indeed the most distinguished feature that might ensure technological breakthroughs and progress further into the 21st century. Understanding innovative strategies for enhancement of understanding and motivation in science is thus at the same time one of the greatest challenges of the 21st century, and by coupling it further to biophysics, Daniel's thesis goes an important step further in redefining its importance for our educational system.

Crossroads of science and education have recently become a fascinating area of research, to which Daniel's thesis makes a significant contribution. Substantial part of the thesis deals with percolation phenomena. Firstly, Daniel presents novel measurement method, which he later uses for two various experiments on water network percolation. The method seems extremely simple, almost on a level of DIY “kitchen physics”, but it compares surprisingly well with much more sophisticated (and expensive, which makes it almost impossible to perform in a typical school or students’ physics laboratories) methods, used for research in scientific laboratories. This by itself is an interesting and worthy achievement, on which Daniel is building the next part of his thesis: bringing contemporary physics topic, namely the percolation phenomenon, from scientific to students' laboratory.

Since percolation is a theory widely used in many disciplines and areas of research, it is a good idea to introduce it into the curriculum of young disciples of science. Nevertheless, one needs to make it concrete and applicable, hence the need to

concentrate on a carefully chosen application. Daniel’s choice is a water network percolation, which occurs during dehydration of two systems: sand grains and yeast. This choice is supported by his experience gained during working with a group which used such systems as their working models. Percolation in both systems is demonstrated through laboratory exercises and introduced for two teaching levels: for bachelor and master students. As proved by the results of this intervention, published in two of his published papers, students were able to conduct quite demanding experiments and acquired basic knowledge about and understanding of the phenomenon. Probably research should be continued on larger sample of students, but the presentation of the intervention, as well as of its results is convincing enough to accept the main point that Daniel tries to make: it is possible and worth the effort to introduce interesting, but not canonical and quite complex topics, which are studied in research labs, into students curricula. It must be emphasized that it is a tricky thing to implement in a simple, practical way a theory which is probabilistic in nature and usually taught by the means of computer simulations rather than experiments. But Daniels deals with it well.

Later in his thesis Daniel presents an experiment which allows to determine thermal conductivity in a typical school laboratory. Again, a very simple idea leads to a neat experiment, which compares with much more complicated and advanced approaches known from “professional” scientific laboratories. Daniel's experiment demonstrates thermal properties of different materials in an interesting way, which highlights the differences between them in a numerical way. Both approaches, introduction of contemporary topics and novel experiments allowing determining numerical properties of discussed phenomena, might influence students' perception of physics and boost their motivation for learning and studying, what basically was shown by Daniel.

In the last part of the thesis Daniel presents two original, active methods of assessing students’ knowledge: in the form of a tournament and a board-game. They were developed to verify not only students' pure knowledge, but also, so important nowadays, experimental skills. This approach connects all the themes of the thesis and strengthens what is for me the main message, which Daniel wishes to communicate: that active methods of teaching should be supported by active methods of knowledge verification. His attempt in this respect was successful, which is clearly visible from his another papers. Students' results obtained in proposed assessment methods were significantly better than others as well as their opinions about proposed assessment methods were very enthusiastic. In that way assessment process might be not a stressor, but rather a motivating factor.

It could be interesting to combine novel experiment with novel assessment method, however I supposed, that it was not done by Daniel since then it will be hard to distinguish the contribution of each novelties into outcomes. Still, Daniel could consider this as a follow-up study. But as can be judged from the published results, Daniel's attempt to bring contemporary physics into students’ curricula, to replace complicated approaches with simpler ones, more intuitive, yet still factually credible, and to verify student’s understanding in the same active way, was a success.

Taken together, I find Daniel's Ph.D. thesis a tour de force in our pursuit of greater motivation for the study of physics, and how the material relates to real life at various

levels of complexity and across different areas of physics and especially biophysics. I find it is amongst the very finest thesis I have had the pleasure of reading in the recent past, with lucid figures, clear and analytically supported argumentation, and a keen sense for the clarity of presentation. In the light of these facts, I also have no relevant recommendations or comments on how this thesis could be further improved.

I congratulate Daniel to his many outstanding research achievements that have culminated in this thesis, and I warmly recommend he is awarded the Ph.D. with the summa cum laude grade, which he highly deserves.

Yours sincerely,

Matjaž Perc

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