Theorist vs Engineer

By Caspar van der Wal

Formation never ends

Formation: this may refer to how a material system gets into some state, but also to the education and intellectual growth of a human being. It is mainly this second case that inspired me for this column. When then considering the formation of science students, I first like to get off my chest that I oppose to the positioning of Theorist vs Engineer (the title of this column series). This framing is maybe still coming from a conceptual mishap that sneaked into the wording used by some circles at least some 20 years ago. It was (or maybe still is) widespread for a while, not only among students, but also in the presentations on study options for high-school students by our Faculty. Groningen is the only university in our country where we have both a study program in Physics and Applied Physics (and for the latter Engineering Physics could be a better name). Then, in discussions, one runs into the need to sometimes really clarify what study you talk about. Whether you mean Applied Physics, or the other one. And for the other one, the wording Theoretical Physics would then be used on occasion (if you still do that: STOP!).

However, in particular for high-school students and starting bachelor students in these programs, this wording is harmful, as it strongly misrepresents the character and beauty of how you can work in Physics and Engineering. I refer here to the fact that some of the most creative and important pieces of work in what is really Applied/Engineering Physics, is work that is 100%

a theoretical. Work that is done with only pen and paper, and running code on a computer. Incoming students that like working in this manner, should thus not get the idea that there is no place for them in Applied/Engineering Physics.

Conversely, we meet very smart and creative students whose talents come out best when using their hands and building stuff, when they try and explore things by experimenting (and who love to do exactly this). These students must know from the start that they can work in the part of Physics that covers fundamental research. Here, tinkering and experimental work is just as crucial as purely theoretical work for discovering new insights. Also here, their unique contribution can make the difference.

So, what is then a good name for the not-Applied-Physics study program? The perfect wording seems hard to find. Maybe we should call that study program Research Physics, but you could indeed oppose that much of the work in Applied Physics is also research. However, with Research Physics vs Applied Physics you at least get a feel what dot on the horizon you get will educated for. And I propose this after considering some ten other options that have more serious flaws.

It should also be noted that once its participants get well beyond the bachelor phase, this whole question on characterizing your work either as Research Physics or Applied Physics just vanishes. To be clear, it is really true that the set of skills, and the focus and mindset, are really different for a good training in Research Physics or Applied Physics. However, once you are well beyond this training (either in academia, in industry, or any other part of society that can use a physicist), you get the best work done by not worrying about the distinction, and to take a style of work that best matches the task at hand. You as an individual, by continuous learning, by setting up mixed teams, or via collaborations, should feel free to diffuse across this artificial border between the core areas Research Physics and Applied Physics. Formation never ends.

In my research group (Physics of Nanodevices and Quantum Devices), our work is all the time some poorly defined mix of Research Physics and Applied Physics. In fact, in these research fields, it is exactly this poorly defined focus that brings the most creative and innovative contributions. As an example, let's take in mind our recent work on semiconductor device-structures made of silicon carbide. For what we want to do, this material is just a transparent crystal (high-bandgap semiconductor), and the real function comes from the electron spin and optical transitions of a few impurity atoms in these crystals. This could lead to devices for quantum-optical communicating over large distances, with as unique new feature that eavesdropping is then really impossible.

In part, this work will have an engineering character already from the fact that this whole research field Quantum Technology clearly has the scenario in mind that one day some of its findings will find widespread application in society. However, while trying to really build and test some ways that seem a good design at first, you just run into so many questions. With material A it seems to work, but it can only work with the optical wavelength of 637 nm. So, is there a material B, C, or D, for which it can work just as good, but with the optical wavelength in a telecom band (roughly from 1300 to 1560 nm)? And then, by just trying, we find that material B indeed works. Not only good enough, but even 100 times better than we can explain by the best theoretical understanding.

So, then we want to know why. Why does it work so much better than expected? And we explore this deeper than what would make sense if it were only and engineering project in industry, because we really want to know what physical principles are missing in our understanding (and as a side note: realizing new experiments for this fundamental work requires some hardcore engineering on the actual measurement setup). But then, while the fundamental insight comes forward, you happen to recognize in some unexpected features that they are a great new tool for a quantum-engineering effort that seems stuck on a rather unrelated problem. In turn, to really demonstrate that this can work, your expertise is really needed, so you deeply participate in designing and optimizing the engineering cycle, and testing of its actual functioning. So, you tell me: are we researchers or engineers?