A New Modelling Army?

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About 460 years ago, during the English Civil War, the New Model Army was formed. It was well organised, the soldiers were well disciplined, regularly paid and well trained. The 22000 soldiers became known as the Ironsides and the New Model Army was a huge influence on government for quite a number of years.

So, although there is a small play on words in the title, this contribution to *Perspectives in CEM* aims to ask how we can better coordinate our army of modellers, how we can ensure they are correctly trained and disciplined. The latter is not referring to self-control but the organisation of the CEM discipline.

What I want to do is to put forward a view about electromagnetics education in this issue and, in the next issue of the Newsletter, compile views that have come to me as a result of this essay, whether supporting, criticising or simply offering another perspective.

As in any form of organisation, different roles need to be played out by different people. So does this imply that when it comes to modelling, everyone should expect to get the same education? In the UK we talk of Chartered Engineers, Incorporated Engineers and Engineering Technicians, while the formal explanations and definitions are more precise and involved (http://www.engc.org.uk/Registration/Register_Sections.aspx) a useful summary is that Chartered Engineers *introduce new technology*, Incorporated Engineers *apply new technology*, and Engineering Technicians *have the skills to get the job done*. While this is a very UK-centric view, I hope the distinctions translate across borders reasonably well.

If we take the view that modelling could be similarly organised, a broad structure could be that modellers will fall into one of the two broad groups:

- Creators. These will develop new techniques, enhance techniques, create packages, develop strategies for modelling structures or provide detailed (mathematical) interpretation of results.
- Implementers. These will use implement models, process the results, undertake sensitivity analyses, etc.

The skills and knowledge of these groups are different; the expectations of them are different but perhaps there is a tacit expectation when it comes to educating them that they are slightly different roles for the same people and therefore the same level and content of education is required.

The traditional approach to teaching electromagnetics is to give a thorough, mathematically based grounding in electro- and magnetostatics, moving on to Maxwell's equations and then using these simple ("a moment to learn, a lifetime to master") equations to study propagation in plane and guided media, antennas and other structures. Once past the almost Herculean task of mathematically analyzing a half wave dipole, students are then permitted to use a modelling package in anger. Of course, in their assignments, they must explain how the governing mathematics of the particular technique give rise to the results displayed. Naturally, simulation and animation tools (such as some of those available through ACES) can be valuable in helping visualisation but the emphasis is, and must be, on a thorough mathematical basis.

In the last 30 years, society itself has changed considerably. We now live in a world of pervasive and passive entertainment. Although there are statistics that ‘prove’ the assertion both ways, a common complaint in the University sector is that there is a constant decline in the mathematical abilities of students entering Higher Education. Also, within this timeframe, the importance of electromagnetics to electrical and electronic engineers in general has increased, for example, electromagnetic compatibility is an issue for most electronic engineers, whether they realise it or not. There is, therefore, a greater pervasiveness of electromagnetics knowledge required in industry. Hence, pretty much all students need to have a good working understanding of electromagnetics, and this should not be limited to the relative few with the ability to visualise the abstractness. Not all of these students will have the love of mathematics that is demanded of a traditional study of electromagnetics. It is also an interesting observation that many with relevant mathematical skills are actually opting to read one of the more fashionable courses such as Media Technology (certainly in the UK). Another factor that needs to be considered is that computers are much more of a tool than they were: clever GUIs and the multi-billion dollar games industry mean students can readily enter a virtual world without a second thought.

So taking some of these factors together we see that more students need to understand electromagnetics but the overall lower mathematical ability (even without accepting the assertion of declining ability, a bigger group suggests a lower group average) means that the traditional approach of starting with the mathematics and then moving to modelling, to make life easier, is now inappropriate. The wider use of electromagnetics as a general design tool suggests that there are two main groups of EM engineers: the Creators and the Implementers, with the different expectations of their knowledge and skills. Does this suggest that we need to turn a standard electromagnetics curriculum on its head?

Perhaps a better approach would be to work ‘backwards’ and start with modelling and using this to build a knowledge of field behaviour. Working from a modelling base, this would allow students to develop the tacit knowledge that dictates the ability to understand how to model, what the results mean in a practical sense and how reliable they are. After all, a carpenter will learn, through trial and error, practice and through the guidance of an expert, how to work wood. He is unlikely to spend many hours studying the theory of complex natural polymers.

In such an approach, perhaps a starting point would be to look at field coupling between two closely spaced antennas, or fields within a motor. Visualising the fields would be a good way to introduce field properties and behaviour, leading on to many other essential aspects. After a structured programme of work developing a good understanding of the model behaviour, looking at the factors that influence the results and visualising the performance, students should be quite competent Implementers. At this stage, the mathematical analysis can be undertaken in earnest. Those without the requisite mathematical knowledge will still have a useful skills set and those with the mathematical skills will be better able to develop a more comprehensive understanding of the meaning of the equations.

So, in creating our New Modelling Army, we should concentrate on the models first and the mathematics last. A possible argument against this is that "surely, if students can't do the mathematics, they will not be able to understand the results". The same sort of criticism was laid at the door of Kepler when he created a table of logarithms based on Napier's work, he was essentially told that unless you can do the calculations all yourself, you can't trust them. When was the last time you created your own table of logarithms, or even checked that the number coming out of your calculator or computer package was correct?

Should we concentrate on developing practical skills, first, in the many and mathematical skills later in the few? Perhaps it is time to move on, and concentrate on ensuring that more students have skills in doing the basics, such as simulating and visualising field behaviour and are able to identify when something is 'not quite right' or understand the basic limitations of their chosen modelling approach. Of those that get beyond a general understanding of fields, they can be more formally educated with a strong mathematical and analytical understanding. In doing this our New Modelling Army will be well trained, well organised and the discipline itself will be well constructed. Hopefully, our Ironsides will be well and regularly paid and will be able cast their influence widely and for a long time.

If you (dis)agree with anything here, have an alternative view or any experience of teaching electromagnetics to support or contradict this essay, please contact us so your views can be included in the next issue of the newsletter (contact apd@dmu.ac.uk or barch@us.ibm.com). Unless you say otherwise, we will assume that you are happy to have your comments attributed.