Is Electronics Boring?

My previous essay touched on electronics, so I thought that my second essay should maybe discuss some of the issues that relate to electronics and education. It must be remembered that these are my own personal thoughts and obviously they might not reflect the feeling of my own institution, but as an academic I feel it is important to express a viewpoint on this subject. It should also be noted that I have recently moved from an electronic department to a computing department, so I've seen computing from both sides of the fence (sorry, for using a metaphor, but I think that a fence is a good description of the divide that can exist between computing departments and engineering departments.

So what's the problem:

1. IT'S SO BORING.

Well, actually, it's not boring. It's just the way that it's sometimes taught. I'm sure that if we could actually see the electrical current flowing in electronic circuits we would all see how beautiful the electronics actually are. It's a beautifully orchestrated movement, which has all the perfection of some of the great works of art in the world. The pulses of light make 1's and 0's, and the 1's and 0's make bytes and words, and the bytes and words make up commands and data, and the commands and data make up logical programs, which in turn make up operations and procedures, which perform the required function. Oh, and it's not just one function, it can be lots of functions for different people over large geographical areas. Maybe the problem is that technologists have never really been taught about how they describe their black magic to others, who do not understand the TLA (three letter acronyms - oops, that's one itself) or the jargon (but that's for another essay).

Isn't it amazing how a computer works? How the data flows as electrical signals around a computer and how it all manages to operate so fast? Isn't it unbelievable how the Internet works, and how two computers can speak to each other in different parts of the world, in a fraction of a second? Isn't it amazing how I can get hundreds of my favouriate songs onto a CD, which, in the past could only take a dozen or so? In fact isn't it amazing how a CD-ROM works? Isn't it amazing how they can fit 10 million transistors onto a piece of silicon, and then make it work like a processor? Yes. You agree? The beauty of electronics and computing has been lost somewhere. Perhaps it's because more and more material was added to the syllabus, and the interesting bits fell off. All the stuff related to audio, video, satellites, and so on, where replaced with nMOS transistors, digital signal processing (DSP) and Boolean logic. The other mistake is that many lecturers think that it's important to go into a lecture and basically regurgitate the material that they have just handed-out to them. What's the point of that? Students can read, can't they? If you watch some of the best presenters they never go into detail, but cover the main principles of what they are trying to present. If someone is more interested in the technicalities then they can read more, in their own time. I've watched many excellent presentations go rapidly downhill once they start to talk about the technical detail of a subject. I tend to use an ancient America Indian (and possibly Scottish) technique called a AW WaH a Coo technique (Pat. Pending), which involves:

AIMS. What's the aim of the lecture, and how does it fit into what we have previous covered? I'm a great believer of presenting a fully-developed teaching schedule so that everyone knows the topics that are covered, each week.

WHAT. What's the concept?

WHY. Why use it? What are the advantages/disadvantages of it? How does it compare with other similar techniques?

HOW. How does it operate?

CONCLUDE. Conclusions on the techniques, and how it will fit into the next lecture.

The Why and How can be interchanged, depending on whether you have to explain the operation of something before you appraise why you would you it.

It is reckoned that less than 30% of the material covered in a lecture is actually learnt from the lecture situation, so if possible, the amount that covered should be the important areas, the rest can be learnt in the students' own time (typically just before the final examination). No-one can really learn the detailed operation of something if they do not already have an understanding about principles of the subject, and why they actually doing it (of course, apart from getting a qualification, which is implied). A lecturer must, of course, assess whether it is better that a student should remember that it is important to remember the exact equation for the flow of electrons in a semiconductor, or whether they are more interested in the concept of electronic flow.

Over the years I have tried to introduce a few modules which were intended to make things a bit more interesting, and also stimulating. One had a very bland name (Advanced Data Communications), but in it I used to teach the principles of real-time compression for images (JPEG/GIF), video (MPEG) and audio (MP-3) and also for general compression (ZIP, and so on). I also included a whole section on PAL, SECAM and NSTC, as much these are important areas to consider when design TV equipment. The students, as far as I could tell, really liked the subject, as it was teaching them new and interesting areas in electronics.

Going from my experience, I often wonder what exactly students will be learning in electronics in ten years time. What with component densities becoming increasingly higher, the printed circuit board (or more recently, the Interconnect Platform) will host nothing but extremely complex ASICs and MCMs, not to mention other, newer IC innovations. These things are almost entirely designed with CAD tools. Then they're tested with CAD tools. The so-called engineering is more like entering-a-specification-into-software. Can a student possibly be brought up to speed with this level of complexity in four years? I figure that if the answer is yes, then no they cannot define a volt - to them it's a number typically between 3 and 12. For those that can, lengthy in-job training is inevitable, because quite simply, industry is moving too quickly for education.

2. IS IT PRINCIPLES OR IS IT HARD SUMS?

Electronics has moved on in the past decade or so. At one time it was important to calculate all the parameters of a circuit, whether it be a digital or an analogue one. But not anymore, we now have computer packages that can predict these for us, using better models than we could ever use. So why is it that academics go into lecture halls and talk about the doping levels of a n-channel MOSFET device, and then get the student to calculate the electron drift. Who cares? Who's ever going to use it? Maybe a designer who's computer has broken down, and he's got to do a rough calculation. Ah, but you say, it's the principles that we're teaching. Ah, but it's not. The main objective is to understand the principles of Maxwell's equations, in English, and they relate to the propagation of an electromagnetic wave, and not how to calculate the intensity of the E-field at any point in space. The best test of whether you’re teaching the principles or just using hard sums to try and explain the principle to someone, who is smart, but doesn't have a background in your subject. If they understand what you're trying to teach, then you've succeeded. I reckon that most of the time academics just use mathematics to make something more difficult than what it is, and are avoiding the difficult questions about what is really happening.

As External Examiner you can really see the weaknesses. Ask a student about the equation for the gain of an amplifier and they'll recite it to you parrot-fashion, but then ask then about what really happens when the thing starts up and moves into its final state, and they're stuck.

In fact, a good test is to ask an electrical engineer what a volt is, and if they say that it's charge divided by capacitance, then ask them what charge is and what capacitance is, and they'll tell you that charge is change in current over time, and so on, and so on. Then, in the end, ask them again what is volt really is.

Here's a few tests if you know any academics in these areas:

Analogue electronics. So how does a transistor amplify power, and where does the additional power come from? Why can you call it power amplification when power is actually lost (in heat, and other things)?

Electromagnetics. So how does an electromagnetic wave really propagate? Does it bounce of the window, and does it go though me? And why do some waves go through me, but others go round me? What's the difference between a magnetic field, and an electric field?

Electrical engineering. Why do birds not get electrocuted when they sit on a power line? Why is it more efficient to pulse power in a power supply (switched-mode power supply) than it is to use a conventional method?

Computing. How do objects make it easier to design programs? How does software actually talk to the hardware?

Microprocessor. What really happens when I press the PRINT key on my keyboard?

When I started out in electronics, in 1977, things were quite interesting. You could actually see the transistors, and you could understand what went on inside the integrated circuits, as there were really just a few transistors which made up a certain logic function. Over the years, though, the actual operating of what goes on inside a device has become hidden.

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