MICHAEL JONES COMPUTER SCIENCE TEACHER

AND OR NOT: GETTING IT RIGHT

Michael Jones brings hands-on Boolean logic gates to his GCSE classroom

Boolean logic can be interesting, enjoyable, and learned in a practical way. This was the promise I made to my GCSE students.

NOT getting it right

Staring at the first year of the new GCSE syllabus, I started wondering how to teach it. In particular, I was concerned about some of the drier aspects, such as logic gates.

To quote OCR,

> 'LEARNERS SHOULD HAVE STUDIED THE FOLLOWING:
> - TRUTH TABLES
> - COMBINING BOOLEAN OPERATORS USING AND, OR, AND NOT TO TWO LEVELS
> - APPLYING LOGICAL OPERATORS IN APPROPRIATE TRUTH TABLES TO SOLVE PROBLEMS'

The key word here is 'studied'. Traditionally, Boolean logic is delivered with: "This is a NOT gate. This is the truth table for the NOT gate. This is the symbolic representation of the NOT gate." Repeat for the other gates. If this works for you and your students, fine. However, for many students it is not fine, and it turns a learning opportunity into a chore.

I realised that most students could understand the theory, but found it hard to relate this to a real computer, full of circuits and electrical signals. To be honest, I didn't feel that my students were getting the full value out of this topic. With the demise in Design and Technology departments across the country, we may have lost that link between the circuit and the theory.

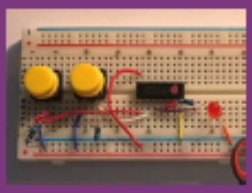
AND getting it right

What did we do about it? This year, our investigation of logic gates has been just that – an investigation. Going back to the very basics of computer circuits, armed with breadboards, resistors and TTL (Transistor-Transistor Logic) chips, we have undertaken a journey into building systems that model Boolean logic. This approach has incorporated an exploration of basic electronics, and taught me not to assume that my students understand how circuits work. In planning the sessions, I made the mistake of assuming an understanding of resistors, anodes, cathodes, and LEDs.

Working with the basic components enabled my students to embed the knowledge that a circuit is essentially the same, regardless of which logic gate they are creating. This allowed us to conduct blind testing of the chips, based on the output produced through the pressing of the two input buttons. The process was very much hands-on and unplugged: not a line of Python or Java in sight, and yet we were programming. Encourage the students to ask the basic question "why does the light go on if I hold down both buttons, but not if only one button is pressed?" From there it is a short hop to creating the truth table.

TTL LOGIC CIRCUIT

With this combination of parts, your students can build and test simple two-input Boolean systems. Just swap out the TTL to change the type of logic gate. Apart from the TTL chips, the components you need are likely to be available from your Design and Technology department cupboard. Add another chip to test the Boolean logic on two chips/gates in series.



Advanced logic

Early in the process I recognised that we had an opportunity to go beyond the confines of GCSE, and launch into A level logic gate investigations, through the development of half and full adders. Using physical circuits that were a natural development of the two-button, one-TTL chip circuit (requiring an additional input chip and some basic components to service the LEDs), we created systems that could add two bits and output the result.

As a result of their explorations, the students now understand Boolean logic. More importantly, they also understand the integral part that it plays in computer systems as diverse as calculators and aircraft control computers. HWO

Michael Jones is a computer science teacher at Northfleet Technology College in Kent. He is a CAS Master Teacher, Raspberry Pi Certified Educator, Winston Churchill Fellow, Chartered Information Technology Professional, PGCE Subject Leader, MIT App Inventor Educator, and Specialist Leader of Education.