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Electronics at Cardinal Newman School

An account of work to develop a new subject to 'O' level standard.

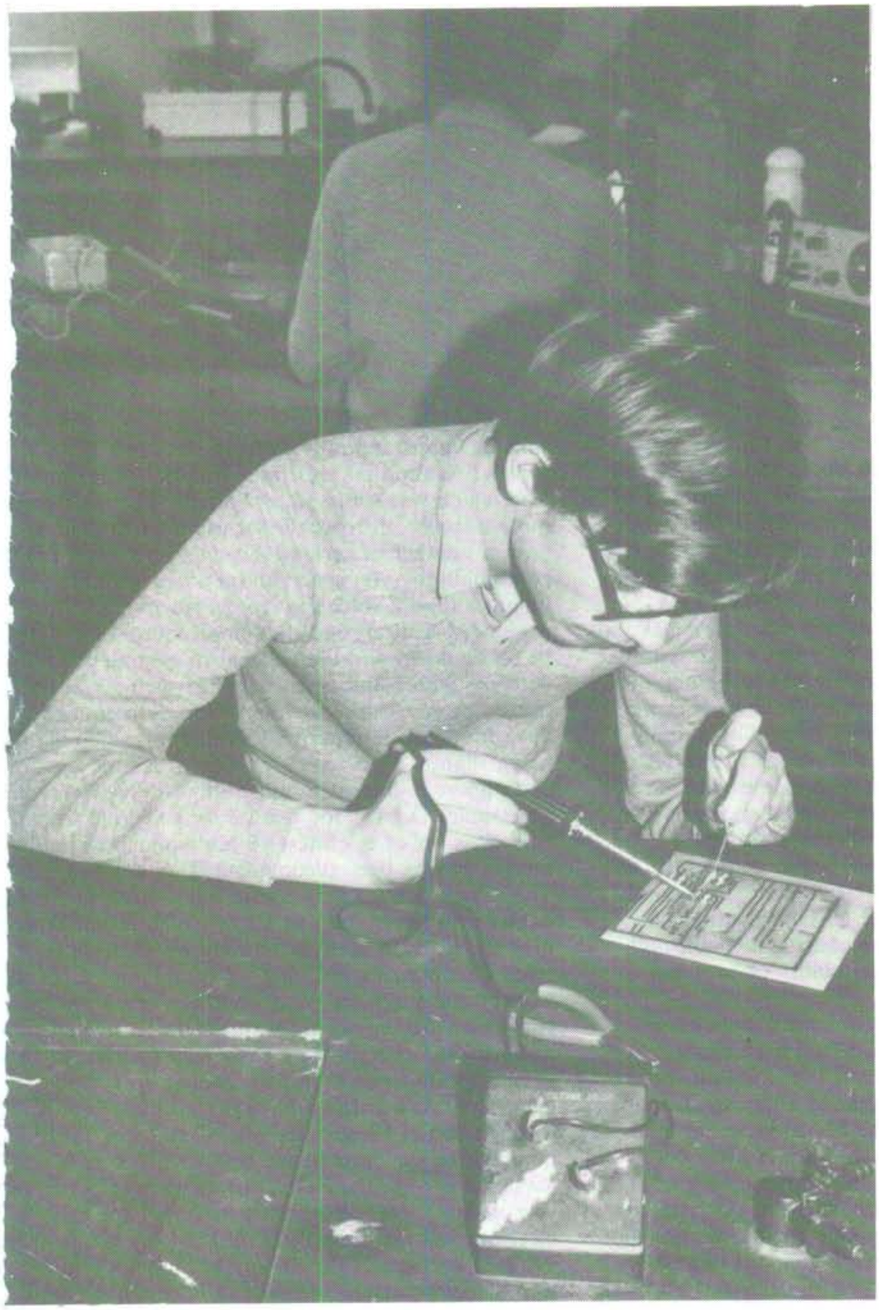
It was some two and a half years ago that electronics entered the curriculum at Newman. Since then we have learnt a great deal and I believe that the pupils have gained immeasurably in ways which we had not really expected.

The subject comes under the control of the Science Department and until electronics courses commenced at school the only relevant experiences possessed by staff were in the teaching of the electronics core content of the 'A' level Physics course and running clubs. Neither of these had much to do with teaching the subjects to the fourth and fifth year pupils. Additionally our knowledge of the subject had developed in a rather piecemeal fashion with perhaps the most constructive element coming from a project to build a burglar alarm for the school. This was at a time when video recorders were disappearing from Coventry schools at an alarming rate and very few schools had burglar alarms installed. The idea then developed among a group of the sixth formers that we would build our own alarm system, undercut the opposition and install it in the school. Beyond that the imagination ran amock. A company manufacturing the system, vast quantities of money being made etc. The governors were impressed with the prototype which having detected the presence of an intruder or smoke alerted the caretaker as to which block had been entered via a link through the lesson bell wiring. Spirits were high especially when we learnt that one of the schools in the city had had a break in where the only item stolen was one of the commercial portable alarms issued to schools by th authority. The system was design built and installe and worked reasonably well with some teething problems. The prime ones were high sided vehicles tearing the overhead wire down between the schoo' and the caretakers house, and T.V. interference.

Well we didn't make our fortune but the exercis has probably taught us more about practical electronics than any number of text books.

Before coming into teaching I had spent eight years in the machine tool industry in applied research and Quality Control management. That experience combined with teaching Physics for a further eight years leads me to believe that there ar serious omissions in the technical education of many youngsters leaving school and indeed even colleges of Further Education and University. I refer to the prime function of any technically creative member of industry which is to be able to apply knowledge and use resources to obtain solutions to new problems. I don't believe that prior to the development of C.D.T. and Electronic courses that any course grasped this particular nettle. Physics has always had an applied content but much of this, if examined critically is of a superficial level partly because of the complexity of understanding required to set applied questions and partly because of the enormous amount of material which is included in these courses. Application means original work which results in a sense of

Project work



Project construction

achievement and increased motivations which in turn leads on to new advances in the development of the pupils. I find it a little worrying that many pupils leave school with an education which includes only the merest spattering of application type work.

It was this thinking and a very interesting talk by Bob Knowle of Marlborough College about the A.E.B. 'O' Level Electronics Course which set us thinking that perhaps we should introduce electronics into the curriculum. The argument was put forward that we should start with an available and well designed electronics option course and build around that third year and non examination (Modern Studies) courses.

The only course which fitted the bill was the A.E.B. 'O' Level course, the others being disregarded for various reasons. Among these was the tendency for many courses to follow a physics type approach to the subject and to aim for a group of post sixteen A Level Physics students. This did not seem the intention of the AEBs course which draws a balance between the electronics system approach and the synthesis of circuit from individual components. However when it came to the problems of mixed ability group teaching the lack of a suitable and compatible CSE was evident. Numerous mode 3's were examined but none were suitable and the writing of our own course on top of starting a new subject would inevitably have resulted in an unsatisfactory job. The only solution was to offer the course as an O level or nothing for the first year. A survey of likely demand indicated over forty interested youngsters and it was proposed that to reduce the incidence of pupils taking the course who subsequently failed to reach the necessary standard we would select the group on their ability and potential to achieve the O level standard. A further restriction which was placed on the pupils was that of having to do Physics as one of their other option subjects. This was considered highly advisable as Coventry engineering apprenticeships and many further education courses stipulate Physics as a requirement for even consideration and electronics does not yet hold that esteemed position. Additionally at the heart of an understanding of electronics there must be an appreciation of electricity which necessitates a certain ability to think abstractly. If only God had made electricity so that you would see it, it would be a very easy subject to understand. Teaching electricity from both the physics and the electronics approach it was felt would give pupils a much better chance of gaining that necessary understanding. Well, all these proposals were rather radical and smacked of elitism and the grammar school system and it was not surprising that when it came to be debated at the Head of Department Meeting that there was opposition. Claims of setting precidents and forming elitist groups were made but the thinking behind the proposal and the intention to introduce CSE Electronics as soon as possible was explained. The proposals were then given the go ahead by a small majority. Subsequently courses were designed for the third year and non examination periods in the fourth and fifth. The third year course was written as a series of work sheets and teacher notes around the 'Adventure in Electronics' book by Tom Duncan. This provided a grounding in the basic ideas giving the pupils some knowledge on which to base an option choice and enabled non specialist teachers to teach the topic. The non examination course chosen was the schools council 'Modular course in Technology'. This was clearly written and ideally suited to the range of mixed ability pupils.

However it was now June and we had forty five pupils having opted for eighteen places on the O Level option and we hadn't any money for equipment. The selection problem was first to be solved. All the pupils came through the science department three times a week for Biology, Physics and Chemistry. The groups in science were divided as two top and six parallel sets. An analysis showed about equal numbers requesting the option in both top and middle sets. Rather than select on past performance in a different subject it was decided that an altogether fairer system would be to set an aptitude test. After some thought and with almost no electronic equipment at our disposal it was decided to make use of some old relays which had been given to the school by one of our local

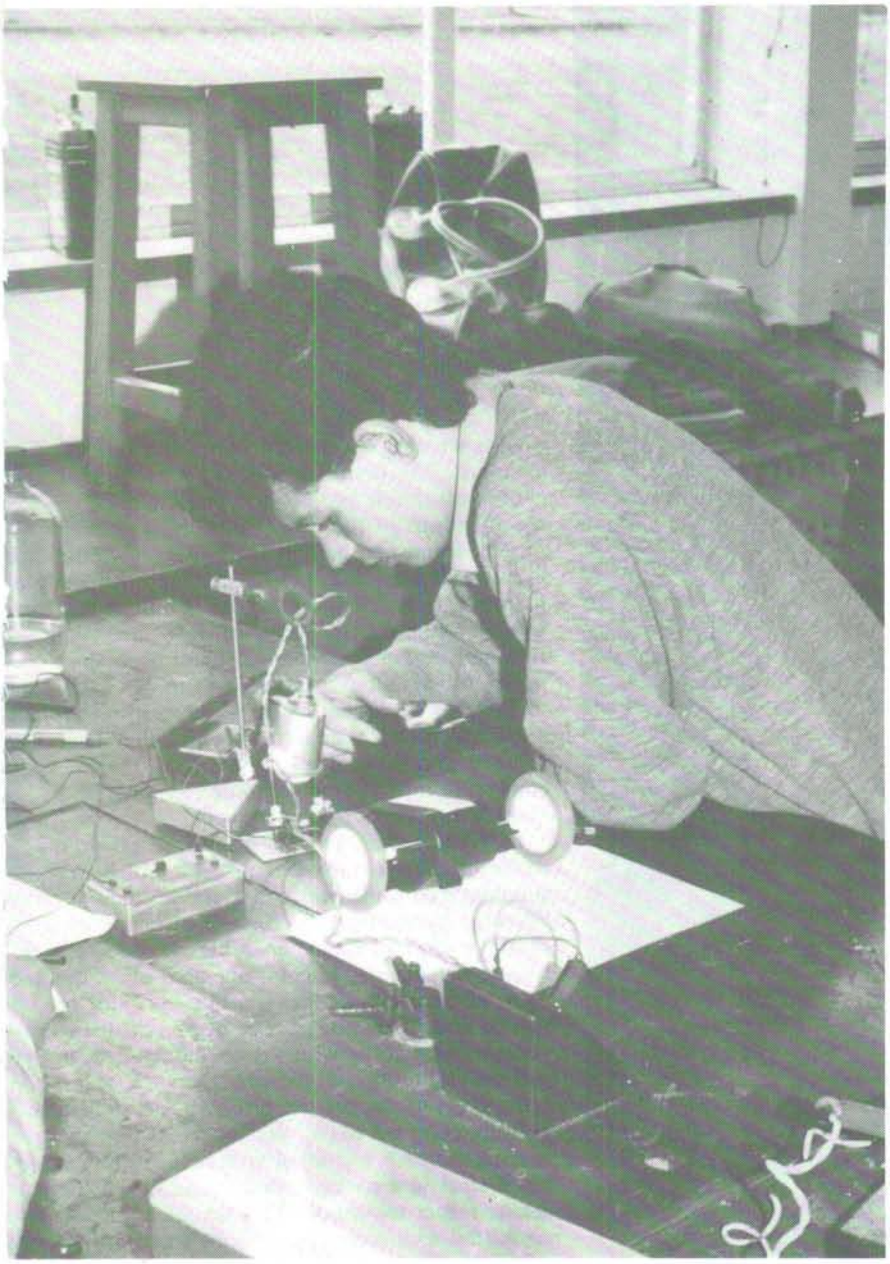
employers, GEC. These were fixed up with leads and plugs and some 12 volt bulbs and holders and plug keys were also obtained. After the briefest of explanations of what a relay was the pupils were asked to build a circuit which made one of the two bulbs go on whilst the other went off when the plug key was inserted. This was then followed by a written question which explained what an AND and a NOT gate were and then by a series of questions a truth table to a simple circuit was to be obtained. The results were very interesting because here we felt we were testing the ability of pupils to apply knowledge and exert their full potential unaffected by their effort or lack of it in previous classroom experiences. Of the eighteen selected, thirteen came from the top sets and five from the others, a number of the top set pupils failing to pass the test. After two years three of the five middle set pupils made the O level grade and all have distinguished themselves in aspects of the course either through mental application, practical ability or problem solving.

At the end of June we still hadn't ordered any equipment although promises had been made. Recognising the seriousness of the situation the Headmaster then made available a thousand pounds from school funds which he hoped he could later recoup from the authority. In all and after the initial teething problems with finance a sum of £2000 was given to set up the subject. At first sight this seemed more than adequate for the venture but we quickly realised that ordering would have to be done with great care. The first priority was the need for a suitable regulated power supply for the room. Individual variable power supplies were ruled out on the grounds of cost. For a group of up to twenty a minimum of ten would have been required and the cheapest in kit form was about £40. Dual and variable voltage power supplies were considered unnecessary for most of the work, and it was decided that a switchable supply of either 5 volts or 9 volts would be quite adequate. A number of 12 volt AC lab packs were available and it was decided to make use of these. The room chosen contained three long benches with seating on either side. At the top of each bench a full wave rectifier was built into an aluminium box which supplied the regulator boxes down the length of each bench. Up to four regulator boxes were placed along each bench and each contained a 7805 regular chip and a simple piece of circuitry courtesy of R.S. Components Ltd to switch it between the two voltages. Each regulator can be used by two pupils and the overall cost of the system was under £50. Subsequently the regulator boxes have been modified to include a 500 mA thermal cut out as it was found that on a direct short circuit the 7805 despite being protected could break down. Soldering irons have presented something of a headache. A low voltage bench supply was already installed in the room and given that safety regulations prohibited the use of mains soldering irons we decided to purchase 12 volt irons. This would allow us to use other equipment such as lamps and motors from the same 12 volt supply. At the time we could find only one suitabl iron which was supplied by Farnell. These althoug quite adequate for occasional use have proved to have a number of serious shortcomings when used continually by youngsters more adept with a sledg hammer than a soldering iron. Principally, prolonged heat around the handle caused the plasti to break down and the element to become loose, with the whole unit constructed in such a way as t make any repair almost impossible. Subsequently w have found an alternative 12 volt iron which whilst being slightly more expensive can at last be repaire and appear a great deal more robust. (see Everyday Electronics Oct 85, for feature on soldering irons).

A class set of microtest 80 multimeters were bought having been recommended by a colleague. These have proved very useful but confusing for th pupils who never seem to know which terminal to plug the leads in and particularly which scale to read. Components ordering we found very difficult with all the suppliers being competitive on one or two items. Minimum order quantities and postage and package charges frequently lead to what at firs sight appears to be a bargain ending up very expensive. As a rule we have placed most orders through Rapid Electronics who seem to be fairly competitive for most items, but we still keep a watchful eye via the electronics magazines on other companies prices. Component ordering for electronics is far more difficult than for most other subjects because of the variety of supplies and the unpredictable nature of demand. The requirement for the third year and modern studies courses was well defined but the O Level presented difficulties, particularly with the prospect of project work. Everything had to be kept down to a minimum and components could not be ordered in the hope of finding a use. Principally the problem lay with ICS and transistors but analysis showed that we would probably get by with two NPN transistors BC108s and BFY51s and a range of TTL gates, 741 op omps and 555 times. TTL ICS were chosen because of their greater current capacity but I am still not sure that CMOS would not have been a better choice. Most of the pupils chose CMOS chips for their project work in order to make use of the lower current consumption.

A class set of veroblocks was purchased to increase component life and all pupils were informed that any project work they did, in which components were consumed, would have to be paid for. Even so I don't believe the average consumable costs per pupil per lesson for an electronics group can be brought down to those for a traditional science subject group.

It was decided to start the group off in electronics with a practical exercise which would give an appreciation of components and skills whilst in physics they would be dealing with electricity and laying the groundwork for the electronic theory later on. The exercise had to be reasonably inexpensive, be useful, teach a range of skills and



Project testing

contain a selection of components. From a short list, an electronic egg timer was chosen. This was taken from a magazine and contained two ICS and could be built for £2.50 including box. The circuit was built in veroboard and seemed to fulfil all requirements.

September duly arrived and the group assembled eager to start but not over anxious to show it. Two girls and sixteen boys. How do you show that number of pupils electronic components being assembled on a piece of board less than 1″ by 3″? The solution came with the recent acquisition of a video camera and television which proved invaluable. OHP transparencies of the holes in the veroboard and component layouts were made and it was forlornly hoped that pupils could construct their circuits from these. Immediately the practical work started we found ourselves dashing from one problem to another around the room and still not managing to keep up with demand. Individual help was required in each case. In science the solution is usually to stop the class and explain a problem but such were the variety of problems and the spread of activities that this simply did not work. Two frequently occuring problems were with the positioning of the breaks in the copper strips and the currect placing of the components. A very simple solution to both problems came with the use of the video camera. This was positioned looking down onto the bench and accurate OHP transparencies of the strips and component layouts were cellotaped to the screen of the television. It then became a very simple operation for pupils to place their work under the camera and check the positions of the holes in the strips and components with the transparency. Even so there were problems with circuits and a great deal of time was spent by myself fault finding. Eventually every one of the egg timers was encouraged to work. A further exercise to make an electronic organ was then completed. This time we used a copper clad board and Dalo pens for marking the circuit board. The construction exercises took much longer than anticipated and when the course was repeated the following year only the first one was done.

The AEB O Level course is a system based course which takes the approach that all circuits can be broken down into simple discrete electronic circuits which can then be interconnected. In teaching this approach a set of electronic modules is a must. At the time the choice of such sets of modules was very limited and a set of the E & L board was bought for us. A work book accompanied the kit and soon the group was busy with building testing and designing different circuits. The class seemed to enjoy the activity but I had two reservations. Firstly there was a tendency for pupils to treat the exercise as a game plugging in module after module with very little in the way of thinking taking place. Secondly there was the question of recording of the work which was very poor in the first couple of lessons. It was found necessary to take a fairly heavy handed approach and eventually the problems were solved.

Next we examined the operation of the transistor and the use of multimeters. Our first attempt was to write work sheets and have pupils making up circuits on veroblocks. This proved a disaster. Firstly the veroblocks were so compact that when the leads were connected to measure different voltages and currents a great mass of wiring developed with crocodile clips touching each other. Secondly pupils had great difficulty with the worksheets and understanding what we had felt was a straightforward exercise. Pupils ended up by wasting a great deal of time and the exercise took twice as long as expected. The wiring problems were overcome subsequently by abandoning the veroblocks in the early stages of non IC work and using matrix boards and pins. This technique recommended in the Modular Technology Course places all components in their relationship to one another on the circuit diagram. Plenty of space is available and it is very easy for the pupils to translate the instructions to produce circuit layouts which resemble the circuit diagrams. The additional time spent soldering is more than compensated for by reduced problems later on. Worksheets were found to work in some cases but problems of misinterpretation and errors which were discovered only after the lesson had finished caused some anxiety. The nature of electronics is such that developments in a pupils exercise happen very

Use of electronic module

rapidly. Components can be changed and measurements taken in seconds and worksheets are one means of taking pressure off the poor teacher who can thus help sort out the problems of those who are unable even to understand the worksheet. Worksheets did however make it a great deal harder to keep a track on what each individual was supposed to be doing and a tendency for discussions to slip from the function of the NPN transistor to Saturday's match was all too prevalent. Additionally an excess of worksheets can lead to attacks of 'Oh no not another worksheet', followed by brain switching off. Many different techniques were tried and not every lesson involved a practical exercise. On occasions when a particularly important aspect had to be emphasised it was found that a teacher led step by step approach was more productive than any other method.

By the end of the fourth year a reasonable amount of the syllabus had been covered and an exam based on past papers was set. Results varied between 20% and 81% with an average of 53% and it seemed that all had learnt something.

At the start of the next year came The Project. This was something which I had viewed with some tredpidation. The AEB stipulate very tight guidelines for this element of the course which is a design build and evaluate exercise. I had seen the standard achieved by some pupils at other schools and I had doubts whether we could achieve that sort of standard. The first task was to get each pupil to choose a suitable project and prepare a specifications of the item. Choosing a suitable project seemed to be half the battle. It shouldn't b too complicated and thereby making it impossible to complete and it shouldn't be so simple that thei was no scope for the pupils to show their ability tc find and evaluate alternative solutions to the problems. My first approach was to ask each pupil to think of a problem or application of electronics related to a hobby or interest which they had. This resulted in a range of proposals from the construction of their own home computer to a blank expression of bewilderment.

By feeding ideas and suggestion we eventually ended up with a full set of projects which were suitable. The range was considerable. A light switcl operated by sensing the presence of people in a room, a wind anemometer, a bicycle speedometer, bicycle mileometer, buggies operated by sound and light, electronic door locks, a bite indicator for fishing and many others. The degree of difficulty varied considerably with the anemometer being perhaps the most complicated. On submission of the project briefs to the moderator all were accepted but it was suggested that the specification for a control system to operate up to ten devices in a room from a single switch was asking rather too much. This specification was re-submitted with only three channels and duly passed.

From submission of the specification there remained about fourteen weeks until the reports were required by the moderator and part of the specification had to include a break down of how this time was to be used. Most pupils regard time a an elastic commodity and I was concerned that we should not end up with a mad panic at the end and unfinished projects. To help maintain the pressure a large notice with WEEK NUMBER was erected and the appropriate number written for that week. Additionally each pupil was given an exercise book into which they entered a diary to record week by week progress.

The attitude of the pupils at this time varied between quiet confidence and a disbelief that they would achieve the finished result. Mark, a boy who had shown flashes of considerable ability when forced approached me and said that he felt that he would be unable to build the reaction time which he had specified. I pointed out his achievement and the fact that, where he had failed it was as a result of a lack of attention and effort which would have made 'Noddy goes to Toyland' a challenge to understand. He eventually agreed with my point but he had of course to prove to himself above all else that he was capable and his past record within school had meant that he had little to judge himself upon.

Each project specification, included a systems breakdown and a colleague suggested that the correct approach was to build the projects with the module boards and then simply translate these into a single circuit. This approach was on the whole

unsuccessful. The E and L boards were excellent for teaching a simple systems approach but the ease of connecting the boards through four pin plugs made them inflexible in application. Only one signal line exists and often two or more were necessary. Also many useful circuits were not available. A time was one notable exception. Mark with his reaction timer was the only pupil to make the full circuit up with modules but others did use some modules and then ran wires to the breadboards to complete the circuit. I think it would be correct to say that other kits are more suited to this work and the Coventry Micro Technology set would certainly have proved more useful, Most pupils ended up by building their circuit on breadboards and with a little initial coercing things were beginning to happen. I was running round like an idiot helping wherever I could. Pupils were coming in of their own freewill after school, lunch times, when they were released from other lessons and on Ash Wednesday which was half-term, fourteen out of the eighteen came into school for half the day to work on their projects. This was a new experience for me. As schools go I would rate the attitude of our pupils towards work as fair to very good and amongst the best in Coventry but to have pupils clamouring to do more work in such numbers was unusual. An air of challenge and excitement developed. James was one of the middle set pupils who had been trying very hard to overcome a very poor reputation in the third year and rather aptly his project was a snooze alarm. It was the first to work and I think everyone in the entire school knew about it. Many problems were encountered and solutions found. Some notably successful projects were most impressive. Richard's was particularly good and was a light switch which sensed the light level, counted people entering a room and subtracted from the total as they left. The light was on if it was dark and people were in the room. He found many problems isolated them and then found solutions. I had immense satisfaction when pupils started telling me where their circuits were going wrong as I regard diagnosis of electronic problems as the highest of the skills and not easy to teach. Of the eighteen projects only one was a complete non starter. Twelve of them worked in their entirety a further three worked in part and the other two worked in breadboard form.

The reports were written up and here a great deal of guidance was required. I eventually gave them a typed sheet of step by step instructions which produced some good logical accounts of the work. Marking was done by myself and forwarded for moderation to the board. I understand that some of my marking was a little too generous but even so I was very pleased with the overall result, with a mean approaching 60%. Mark's reaction timer scored highly and James' snooze alarm would have done even better if he had paid a little more attention to the report.

I can now look back at the two years of very hard work and I believe I can see benefits which have been *accrued by* this course, and I don't believe that these experiences would have been gained by these pupils by the undertaking of any other course. I believe there are four areas of improvement beyond just the learning of another subject. Firstly the generation of enthusiasm by the project was remarkable and that seemed to almost awaken some of the group to the fact that academic school could be other than tedium. Secondly and linked to it was the fact that for Mark and others it provided a real sense of achievement. A box of electronics which makes a sound and flashes lights etc. is far more tangible in pupil achievement terms than is the ability to answer a question about a certain topic in Science. Certainly in personal development terms Mark has benefitted by doing something he had previously felt was beyond him and unquestionably he surprised himself. Also he had something to take along and talk about at interviews. Thirdly there is the well attested scope which the subject possesses to encourage and develop logical thought and problem solving. In a technologically developing society the fund of required knowledge is bound to change but the necessity to think clearly and solve problems will never change. I happen to believe that electronics is probably better than technology in teaching these skills as the nature of the subject makes it very easy and relatively inexpensive to find and test alternative solutions to a problem. Finally the project necessitates the use of magazines and literature to find the appropriate solutions to the problems. The situation of the project places the pupil in a realistic work environment. Resources are available, a problem is at hand and the important thing is to apply the resources to seek a solution to the problem. That has to be a valuable experience.

As for the future, we have learnt much and shall further develop this course, together with the third year and modern studies course. A CSE Electronics courtesy of Dave Snashall of Babbington College, Leicester, looks a possibility provided we get exam board approval. I don't see A level Electronics on the curriculum although there is certainly some demand. My only regrets so far are that despite every effort the subject is very much perceived by the pupils as a preserve of the boys and how we attract more girls to the subject is a matter to which I am giving a good deal of thought.