**Title:** An investigation into how using simulation software may facilitate the understanding of electronics theory in Year 10 pupils.

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**Research topic:** Technology-integrated pedagogical strategies; Secondary Design and Technology Electronics teaching and learning.

**Geographical area where research conducted:** England – Eastern region.

**Educational sector of participants:** Secondary.

**Abstract:**
This small-scale case study examined how simulation software (in this case, "Crocodile Technology") could be used to support the teaching and learning of electronic theory with year 10 D&T students. The approach employed was based on the idea that the use of software would raise pupil's levels of motivation and engagement with electronics theory work. Over one term, a mixed ability year 10 group of pupils were taught a wide range of electronic theory, with "Crocodile Technology" software being the main tool used to deliver and explain this work. Evidence about pupils' levels of engagement, motivation and understanding were gathered by means of observations, questionnaires and collecting work from the students. The main findings of the study were:

- The use of the software was a significant motivating factor, and students were highly engaged in tasks set.
- The software allowed students to learn through trial and error.
- The software allowed effective differentiation of tasks and outcomes.
- Students were able to produce good quality notes
- The use of this software allowed the teacher to spend a high proportion of his time actually teaching.
- This software allows very able students to learn at a higher level than a non specialist D&T teacher may be able to teach them.
- Some students experienced difficulties with lost files and printing problems.
- The use of a computer based approach can provide a distraction to learning in some instances.

**Findings:**

- The use of the software was a significant motivating factor, and students were highly engaged in tasks set. In all of the 7 lessons formally observed, the observers commented on the high level of pupil engagement. This was also reflected in the pupils' views – out of the 15 pupils, only one believed that he had not worked well in the lessons. Two thirds of the students found the lessons interesting, but when asked their views on using the software, 13 out of 15 said that they liked using the computers.
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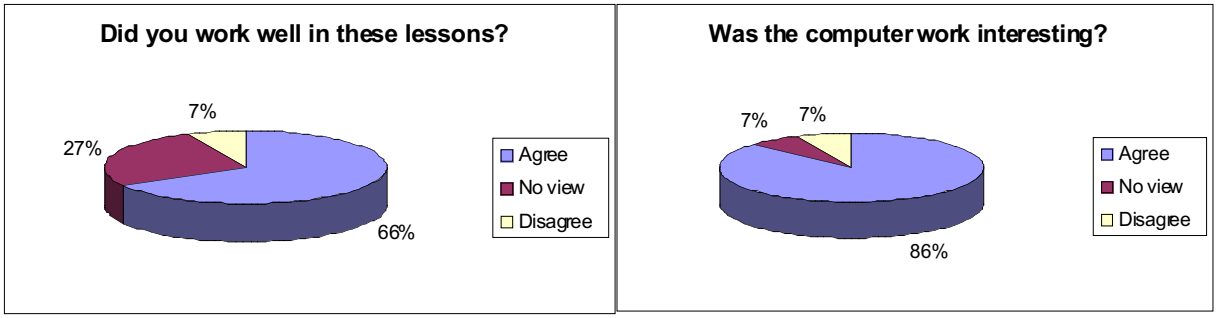
***Pupils views on how they worked / whether the use of computers was interesting.***




- The software allowed students to learn through trial and error. By experimenting with circuit layout and the values of components, students were able to see the virtual results. When teaching about logic gates, one student was unable to understand the concept of what an AND gate does, but by trial and error he was able to experiment with the inputs and thus determine the range of possible outputs.

- The software allowed effective differentiation of tasks and outcomes. In each lesson, once a concept had been explained, a series of tasks were set. At the end of completing these tasks students produced notes by cutting and pasting the circuit simulations into a word processor and adding appropriate text. As students were working individually, it was possible to set extension tasks for the more able, which often involved them using the help function and the tutorial to find out more about certain components and then to build circuits using them. As they were able to work independently, the teacher was able to use his time to help the less able to complete their work.

- Students were able to produce good quality notes. By word processing the results of the investigations, students were able to paste the circuit simulations into text documents to produce professional looking notes. Many students also added charts, and used Word Art and arrows to annotate their work.

- The use of this software allowed the teacher to spend a high proportion of his time actually teaching. When teaching electronic theory, if any degree of practical experimentation is used then the teacher inevitably spends a significant amount of time managing the resources. As this is an entirely virtual system, there are fewer resource management issues to deal with,

and so a higher proportion of time can be spent dealing with students learning and understanding. When using (for example) a breadboard to experiment with circuit design, a teacher inevitably has to spend a significant proportion of his time acting as a stock controller. There are organisational issues to deal with using simulation software, namely the organisation of file management and controlling printing, but this is much less significant. It was therefore possible to plan the lessons to allow the teacher time to circulate and deal with students' conceptual understanding, rather than their practical difficulties.

- This software allows very able students to learn at a higher level than a non specialist D&T teacher may be able to teach them. Whilst the ideal is that all teachers are experts in their fields, the reality is that with D&T a shortage subject and only 27% of schools currently offering any form of electronics option[i], there are relatively few teachers who are experts at teaching this subject. Whilst the teacher in this project has some experience of the electronics industry, it is not his main specialism. On several occasions there were students working through the tutorial activities, where they were learning theory which the teacher would have struggled to teach.

- Some students experienced difficulties with lost files and printing problems. Although the resource management issues are easier when using this system, several pupils lost time as they could not remember where they had saved their work, or experienced difficulties when trying to print it out.

- The use of an ICT based approach can provide a distraction to learning in some instances. As this software is invariably loaded on machines which have other software on, there is the possibility of students going off task to investigate other programs. This only happened on one occasion during the course of this research. A more common time waster was students producing "neat nonsense" – i.e. notes which looked great but had very little content.

**Participants' information:** Students – Year 10, mixed ability, 14m 1f
Teacher – Head of D&T

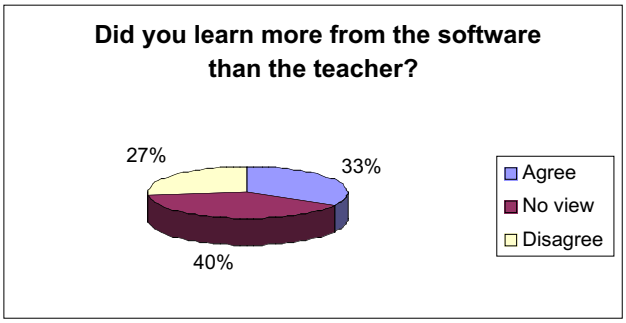
**Equipment and materials used:** Students were taught in an ICT room, which had 14 networked PCs and 2 printers in it. Each PC had Crocodile Technology loaded on it. This is a simulation package, which allows circuits to be virtually constructed and run, with diagnostic features attached. Microsoft Office was also used extensively in this work. In addition, students were given photocopied sheets with information about each item being studied. These were cut and pasted from textbooks, and had questions alongside which had been produced by a number of Teachers.

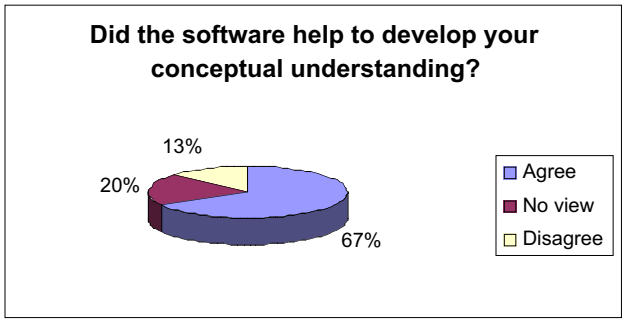
**Applied method of analysis:**
Within the school where this research was undertaken, the GCSE D&T students have one double lesson (1hr 40mins) and one single lesson (50 mins) each week. During this research project, the year 10 electronics group spent each double lesson involved in project work, which consisted of designing and making an electronic product. As part of this project work, students would spend some time examining the theory work behind the products they were making. In the single lessons, students worked purely on electronics theory. This research looked at how those theory lessons could be taught using Crocodile Technology. During the course of this project, 7 lessons were taught and formally observed by another teacher / researcher, in order to provide an independent view on the activities taking place. At the end of the project students filled in a questionnaire to give their views on the software and how it had affected their learning. Throughout this, the researcher kept a research diary, noting significant points. The lesson observations were used to establish qualitative data, particularly looking for recurrent themes which appeared in different observers comments, an example being that all observers commented on how well the pupils were engaged with the tasks set. By using the questionnaire, it was possible to gain more quantitative data, showing how the pupils' perceptions matched those of the observers and the researcher. The triangulation of approaches offered by having a research diary, independent observations and statistical analysis, allowed a high degree of confidence in the findings where the evidence was in accord for all three methods.

**Conclusions / discussion:**

A clear merit of using a software based system to teach electronic theory, is that almost universally students would prefer to work on an ICT based task than a paper based one. This was clearly demonstrated by the students in this study. By keeping the tasks ICT based, students were quite keen to produce written notes using Word. If this had been done as a paper-based exercise, it is unlikely that the students would have been so keen to do it. By using Word, even the weakest students were able to produce professional looking notes, which further motivated them with this work. As a side benefit, students were practising and developing ICT skills above and beyond those needed in a D&T lesson.
The ability for students to see a virtual result instantly was evidently a significant motivating factor. Moreover, by eliminating any physical construction, there are no dry joints / broken tracks / damaged components and so forth. In practical lessons some students experience great frustration when a proven circuit will not work and there is no obvious fault. This system does away with that problem.
Two thirds of the students believed that the software had helped them to develop their understanding of the concepts of electronic theory, but they were fairly evenly divided as to whether they learnt more from the software or the teacher.

***Pupil's views on how their understanding developed.***




The use of the tutorial and help functions enabled very useful differentiation to take place, offering the opportunity for all students to achieve to the best of their ability. This also allowed the teacher to spend time dealing with learning issues rather than class management ones.

**Recommendations:**

- Lessons were structured such that there was a short talk from the teacher explaining some concepts / theories, and then students were set tasks. These usually involved producing circuit simulations and finding out about certain components. Students then produced notes (using Word) to explain what they had done. This worked well.
- It helped to have real life components when talking about them, so that students would make the connection between what they see on screen and what they actually looked like.
- Tasks should be structured so that all can achieve the basic ones, and there are more complex tasks for those who are able. Using the help and tutorial functions allows student to work independently.
- Where possible, tasks should be based on real life scenarios.
- Although the software is a powerful tool, in this project teaching was found to be most effective when several approaches were combined. To that end, there were practical design and make lessons running alongside the theory lessons. In the theory lessons, as well as didactic input at the start of each session and individual support, students were also given printed notes. These often had questions on and were used as homework tasks. This made it possible for the teacher to assess the level of learning that was taking place.
- It is advisable to establish a file structure and protocol for students to save their work in. Equally, access to reliable printers is important.

**Research evaluation:**

Over the course of this case study it has become very clear that Crocodile Technology is an extremely effective way of engaging students in the study of electronic theory. Equally, it has been possible to see the benefits that it offers in allowing students to manipulate circuits and see the results of these changes. What is more difficult to ascertain is how effective the software has

been at helping the students to develop their understanding. Two thirds of the students thought that they had developed their understanding through the use of the software, but this case study has been too short to substantiate that claim. This could be followed up as part of a larger study, which would incorporate the use of control groups and base line data. By undertaking this study, the researcher has been able to reflect on what is the most effective means of delivering electronic theory to students, and will use this information in the development of a scheme of work for KS4 students.

[i] DATA Annual survey of provision in Design and Technology 2000 / 2001 (http://www.data.org.uk/)