APPLICATION OF INFORMATION AND TECHNOLOGY IN THE TEACHING AND LEARNING OF SCIENCE IN SCHOOLS

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Abstract

This paper relates to the over-riding concern about the role of information communication technology,(ICT) in education; the-extent to which the claims of policy makers, administrators, publicists; politicians and bureaucrats are borne out in the reality of teaching and learning in and outside the classroom. This is an in-depth case-study evidence that can be used as the basis for generalization on the effective use of ICT in the teaching and learning of science in schools. This paper reviews the issues in the development of a design initiative for furthering our understanding of the problem of knowledge transformation in science education through information and communications technologies (ICT).

Introduction

In this post-modern era the status of science, and scientists, in the society has been severely compromised. Certainly we cannot assume any consensus that science is a " good thing" even in the most technologically advanced society. Issues such as pollution, health risks from the nuclear industry, and the generic modification of food crops have helped to dislodge scientists from any pedestal that they might once have occupied. The numbers of students wishing to study science in the higher institutions has fallen, and the trend continues downwards. Certainly low status, suspicions of the role of science and low pay compared to commercial world do not make science an attractive career choice.

A major factor in this is the current model of science offered in schools. It fails to effectively prepare students for their experience of science beyond school and to present science as fascinating; interesting and rewarding subject at the fulcrum of human existence.

Thus, in the science community outside school, the use of computer-based technologies has become a routine part in scientific research. Indeed one of the first internet protocols was devised by scientists at the European center for research in particle Physics, so that they could exchange data with colleagues in Italy and the Rutherford laboratory in Cambridge, UK,(Segal. 1995).

Today, it is unthinkable that scientific research could proceed without access to on-line databases, electronic mail communications with other institutions, the use of sophisticated monitoring equipment for data collection, powerful spreadsheets and database packages for analyzing and manipulating that data and publishing software for producing papers and reports. Here, we see the mismatch between pedagogic subject knowledge in science education in schools and the applied academic knowledge of the scientific community.

A comparison of ICT use across curriculum reveals that secondary science has failed to embrace ICT, despite a vast investment of time, money and human resources.

Meaning and Application of ICT to Science Schools

ICT (information communication and technology) is the technology required for information processing. In particular, it refers to the use of electronic computers and computer software to convert, store, protect, process, transmit, and retrieve information from anywhere, anytime. Through the 1990s, a series of research findings highlighted the potential of ICT in the science curriculum.

A review by Crook (1991) of a range of ICT use through the curriculum, including science, showed that students using ICT took greater responsibility for their own learning. Watson L.M, Baggot la Velle and Nichol (1993) investigated the impact of ICT on Students achievements in science (amongst other subjects) and provided evidence that students spent longer time on learning tasks. Changes in Students attitudes and motivation for learning have also been seen, for instance in Biology lessons where students used an artificial intelligent tutor, there was clear evidence of increased enjoyment and interest (Shofield , E.W Eurich-Fulcer R. and C.L Britt 1993).

Also, in 1993,Morrison showed an enhanced sense of achievement in learning amongst students using laptops for a year across the curriculum, including science.

MaFarlane and Friedler (1998) showed clear evidence of enhanced learning through the use of data logging. But all these were individual studies whose results were not replicated in classroom practice nationally.

The spread of good practice faced almost inseparable barriers. Through the 1990s, the use of ICT application in science lessons remained very patchy, although there was good evidence that many teachers used it for personal and professional purposes, (Goldstein, 1997).

McKinsey (1997) showed that only 5% of science teachers regularly used ICT in their lessons compared with 34% of mathematics teacher. Science teachers cited many reasons for not using ICT and these are

> Generic software provided with network
> Distance between ICT and science curricula.
> All students must work on computers all the time in a lesson
> System problems =Lesson time wastage
> ICT irrelevant to science curriculum
> ICT does not contribute much to students' learning of science.

Yet the power of ICT to engage and challenge students is well documented (e.g Scaife and Wellington, 1993) in pockets of good practice. To overcome this requires a pedagogical shift (Linn, 1999; Baggott la Velle, L.M, A.E. Mcfarlane and R. Brown, 2001). This is important, because the pedagogical approach adopted in traditional classes has been shown to have a major influence on the cognitive achievements of students (Harbin and Wubbles, 1995). Cox (2000) gives examples of this, including the place of the computer in the teaching \ learning relationship -she calls it "the computer as a third person." Evidence from research carried out by Jean Underwood suggests that teachers move to a more managerial and facilitating role when using 1CT, and away from being the provider on centre stage (Underwood, 1988).

The potential of ICT to change teaching and learning styles is recognized. There is consistent evidence from the earliest days of educational ICT that when students are given autonomy to derive and test their own ideas and understanding, their ways of learning change, and there is improvement in their understanding and achievement. But this requires a context within which such exploration and testing can take place.

One of such context is simulation. The advantages and disadvantages of using ICT simulations in the school laboratory are well-documented (Scaife and Wellington, 1993,Baggot, 1998).

As a result of early work which demonstrated that students were able to engage in investigations that were not only impossible to replicate in a school laboratory, but also above the mathematical abilities of learners,(Papert,1980,Kurland and pea, 1983, Cox 1984,CERI,1997), a substantial number of simulation and modeling programs have been developed and evaluated.

Bliss J, Meller, R.Boohan, J. Ogborn and C. Tompsett (1992) distinguished simulations as the exploration of existing models, and modeling as the expression of learner's ideas.

Musa (1998), has Emphasized that Facilities are Universally Acclaimed as the most Effective Methods; if well used for Passing of knowledge Across to the Students

Balogun, (1982), narrated that the provision of equipment contributes to the achievement of our educational objectives. This expert writer holds the view that for people to achieve their educational objectives there should be provision for equipment that will aid teachers during the course of teaching. However there are some schools that there are no laboratory facilities at all for-teaching of science not to talk of computers.

Mellar , J. Bliss and J. Ogborn, (1994), demonstrated that students were able to investigate much more complex models if they were provided in simulations than if they had to build them-on their own.

Margaret Cox (2000), has reviewed research carried out over the past decades on the educational use of ICT-based simulations and modeling, and concludes that the main contribution made to students understanding of science is the acquisition of investigative skills and improved understanding of some scientific concepts and processes (Cox, 2000).

The use of ICT in science enables students to develop novel strategies for problem solving by building models and creating new rules,, (Boohan,!994). They are able to complete tasks of greater complexity, than they would be able to without the scaffolding effect of the software (Widerman and Owston,1988). Students are able to test their own hypotheses by making informed predictions (Linn and Songer,1993). They develop higher order thinking skills and are able to engage in complex casual reasoning (Mellar, 1994). Students have been shown to use more exploratory language to arrive at choices through discussion. The range of simulation and modeling activities allow for both expressive and exploratory learning activities.

The case study presented below involved a collaborative partnerships between science teachers from two inner-city secondary schools, researchers and teacher educators, together planned and implemented a "science design initiative" which was intended to be a longitudinal case study on how ICT can be used to enhance learning in science.

In a preliminary interview, the teacher, "A" was probed about the historical and contextual influences on his pedagogical attitude and practice, his models of teaching and learning, his strengths and areas for development, his attitude to change in science education and his attitude to ICT in science.

The teacher, A, has taught in the school, a mixed secondary school on the outskirts of a large city, for twenty years. Prior to his teacher-training course, A, whose degree subject was biochemistry, was working with an Agricultural Research Council. This experience was very formative in his attitude towards school science. Over the course of his career, to his regret, A has seen the amount of investigative practice work diminish, to be replaced by "fabricated" practical exercises for the purpose of assessment within the National Curriculum, A believes that boys are more confident in science lessons than girls.

On the subject of ICT in science education, A sees it as a major motivating factor for pupil's learning. Although he accepts that it is a good alternative, ICT should replace practical work, but if the laboratory-based practical approach is possible, it should take priority over ICT. Ideally, ICT should be available in the lab as a data collection and analysis tool, although this is not the current situation in his department. A's experience with simulation and modeling software has been positive: it has encouraged him to reflect on his exposition and exemplification of scientific principles, in relation to the students' learning. A chose to work with a mixed ability S.S.S.I class (14-15 year olds), in their first senior secondary year. The topic for the research was electricity and magnetism. Students will have addressed this topic in their Junior secondary school, where, according to the National Curriculum in science, they will have covered the construction of simple circuits using batteries and switches to power a range of devices such as lamps, buzzers and motors. Students will also have undertaken work to show that changing the number or type of component in a series circuit can make a bulb bright or dimmer. They should also have covered the representation of series circuits by drawings and conventional symbols. Students were pre-and post tested for their knowledge of the topic, and a selection of six students (3 girls and 3 boys, one from each ability level, high, medium and low for the class) were interviewed about their understanding of the topic before and after the . teaching. Standard data on pupil's cognitive ability and achievement were collected. The lessons were videoed, using both a fixed and a roving camera. At the end of the topic A viewed the videos and engaged in a reflective discussion with the researcher. Video of students working in the lab and. computer room provides evidence of multi-modal learning. For the SDI, A planned a combination of traditional laboratory practical work with circuit boards in which pupil, working in pairs, built simple circuits, and measured current and voltage, and work in the computer suite using the interactive simulation program "Crocodile Clips". This software enables students to manipulate virtual electrical: circuit components, such as lamps and batteries etc. in ways that are analogous to "real'[1] laboratory"-work, but with the unreliability and lack of resource removed. They can safely apply various currents and voltages to the circuit without destroying any equipment. Circuits are quick to build, and can be saved and printed. This computer software application chosen for the SDI contains elements of both simulation and modeling and they allow for both exploratory and expressive learning activities (Mellar and Bliss, 1994). Lesson 1 took place in a laboratory. The class undertook practical work using circuit boards. They built series circuits, measured current using an ammeter; taking current reading at various points in the circuits and went through units of current. A introduced the measurement of voltage across various components of a circuit, and units of voltage. The class work included reading and answering questions from a textbook

(EUREKA). Lesson two took place in the computer suite and students were required to use the simulation program "Crocodile Clips" to build virtual circuits by dragging and dropping icons of electrical circuit symbols and "wiring" them together. Students worked from a printed worksheet at individual workstations. They built the circuits, measured current and voltage, and saved the circuits to their designated place on the school server. The class,' (22 Students), did the pre-test, which was the end-of-topic test for the module on electricity and electromagnetism from the 'S scheme. The average score for the class on the pre-test was 32.8%. The post-test, which was a repetition of the EUREKA end-of-topic test, produced a class average score of 57.1%. After the practical and computer-based lessons, three consolidation and extension lessons took place. Then, the whole class was given the end-of-topic test again, and the sample students were interviewed. Interview questions were designed to encourage them to articulate their new understanding of specific points as demonstrated by their responses to questions in the pre-and post-tests. The six students were also asked about their preferred learning strategies for the topic. They were asked to put in order the following strategies:

Practical work using the circuit boards
Teacher explaining - to whole class, small group or me on my own
Computer work with Crocodile Clips program
Class work - making notes from the EUREKA book, copying diagrams from the board.

The students were also asked if they had a computer at home and how they used it.

1. Student 1 (low ability boy)

In the post-test, student 1, scored 40% - an improvement of 15%, although short of the class average by 17%. However, in the post-interview, he could not explain the difference between, or characteristics of a series and parallel circuit, or remember why he had got the questions right in the test. He showed no real understanding of the measurement of current and voltage, of the differences between them. Asked about his preferred learning strategy, student 1 put working on the computers first, followed by class work, the teacher explaining to the whole class, and finally practical work in the lab. He had worked with Crocodile Clips in his technology lessons, and found the circuit building easier and quicker. He has a computer at home, which he enjoys using and finds easy. He uses it for playing games, researching on the inter-net, and has used Word, Publisher and PowerPoint for his English homework. Video evidence from the lessons shows Students 1 engaged in many off-task activities, such as drumming his hands on the bench as the teacher explains and instructs from the front, and "playing" with the apparatus in the lab rather than doing the required task. In the computer room, he worked alone on a computer, and sat some distance away from his partner in the lab. He worked through the Crocodile Clips worksheet quite rapidly, successfully making and saving the circuits.

2. Student 2 (low ability girl)

In the post-test, Student 2 scored 25%, lower than the class average of 51%. In the post-interview. Student 2 was more forthcoming with the researcher. She said she had done circuits before, and articulated a clear understanding of conductor and insulators. However, she remained unclear about the difference between and characteristics of series and parallel circuits. Particularly, she found the concept of a complete path for the electricity to flow very difficult to comprehend. She failed to name the ammeter or the voltmeter when shown their symbols.

Student's 2's preferred learning strategy was one-to-one explanation by the teacher. After this she named next working on the computers with the Crocodile Clips program, saying that she found the circuits easy to make. Citing enjoyment as a reason, the practical work in the lab came next in her choice of learning methods. Lastly came the class work, and of this she preferred making notes in her book. This student did not have a computer at home, but sometime used the school machines, or that of her sister (who lived away from the family home). Video evidence of this student is scant, but she was seen struggling to make sense of both the apparatus in the lab and the computer program.

3. Students 3 (mid-ability boy)

In the post-test, which he did later than the rest of the class, and for which he had not revised, Student 3 scored 25%, a 20% drop from his previous performance. At interview he was still unclear about series and parallel circuit but with help he was able to say what would happen if various lamps were removed from the circuits, demonstrating his understanding of the idea of a complete path for the electricity. He remembered that voltage splits in a series circuit Student 3 said that he preferred one to one explanations form the teacher as his preferred learning strategy. His next choice was of the computer work with Crocodile Clips, which he found easier to use than the laboratory circuit board apparatus. It "easily told you it was a complete circuit". He also liked the way that the program made good mistakes in drawing a circuit diagram. Oddly, then he next chose copying circuit diagrams from the board as his next most favoured learning strategy. Lastly came the practical work, which "was good and helped, but not as much". Student 3 has a computer at home, but as it does not have a printer, he does not use it for homework. His most frequent activity is time spent on the inter-net.

4. Student 4 (mid- Ability girl)

In the post-test. Student 4 fared less well, scoring just 40%, a drop of 5%, and significantly less than the class average. In the post-interview she confirmed her poor comprehension of the differences between series circuit, clearly explaining why removal of a lamp would cause the others to go out. She admitted that in the test, she had based her answer on a combination of vague memory from her work in Junior secondary school and guesswork.

She cited practical work as her preferred leaning strategy for the topic of electricity, followed by copying circuit diagrams from the board, teacher explaining to her and her partner in the lab, and finally the computer work.. She had got on quite well with the crocodile clips program, but having built the circuit and answered the question, failed to save her work, which was subsequently lost. She said that the crocodile clips program made it easier to make the circuits than either the circuit board apparatus or drawing them by hand. She has a computer at home, which she uses for writing stories (word, publisher and clip art). She is not allowed to use the inter-net on school nights, or for very long at the weekends.

5. High ability boy

In the post-test, Student 5 scored 70%, a gain of 15% demonstrating improved understanding of measurement of current and voltage electromagnetism. In the post-interview, he clearly showed his understanding of the range of the topic. He understood and could explain that current is the same wherever in a series circuit that you measure it, adding that he had discovered this by practical experimentation. He remembered that voltage splits in a circuit, although this was not apparent in the test paper. Video evidence of student 5 working in the lab and on the computer shows a boy very much engaged and motivated by his work. Student 5 preferred practical work with the circuit boards as a learning strategy for this topic, saying that this way enabled him to "work it out on my own'[1]. This was closely followed by the computer work, which he liked as it presented the ideas in a slightly different way, and he appreciated being able to save and print his circuit diagrams. Thirdly, he chose class work, as he liked the Stan's book because they provided notes and diagrams together. He found the teachers explanations easiest to learn from when he was in a small group. Student 5 has a computer at home, and uses it for his homework, games and the inter-net.

6. Student 6 (high ability girl)

In the post-test, Student 6 scored-65%, an increase of 5%. She had gained an understanding of the measurement of current but not voltage. In the interview, she said that, she remembered well, the basics of the topic from primary school, and that was why she had done well in the pre-test. She was clear about the properties of series and parallel circuit. From the lessons she had not grasped the concept of voltage and how it is affected in a circuit. When lead in the interview, she came to a quick understanding. Although the increase in her scores was perhaps less than might have been expected, she could articulate her knowledge clearly. Video evidence of student 6 at work in the lab, shows a quiet, conscientious approach. Little oral collaboration with her partner is evident, but much understanding is demonstrated by her manipulation of the equipment. At the computer, she works silently, consulting the worksheet and making or responding to the odd task-related comment from her immediate neighbour. Occasionally she looks around for the teacher, but never succeeds in attracting his attention. She returns each time to the task on screen, and works her way through it alone. She succeeds in completing the tasks and saving her work. Asked about her preferred learning strategies, pupil 6 opts firstly for the practical work; giving as her reason "you are experimenting and finding out the answer. This makes it interesting and you learn more". Writing in her book was the next strategy. Third came the computer work, which she said helped her a bit, especially the task of testing the voltage at various places in the series and parallel circuit. This was "...fun...you can keep trying and it doesn't take too long". She thought that her understanding from the teacher's explanation was clearest to her when he taught the whole class. Video evidence suggests that in this situation, student 6 listened carefully to all that is said, and watches for the range of other clues to help her learning. She has her own computer at home and she uses it for homework. She has a science CD with information, a help section and tests. She has unrestricted access to the inter-net, but only uses it rarely for research.

Conclusion

The test results, both pre- and post- do not reflect the student's understanding of the topic of electricity. They can present their knowledge and understanding more fully, clearly and effectively in conversation, especially when the discussion is structured to provide the necessary support to elicit knowledge. Such was the case in the post-interview. Analysis of the test scripts showed that some question which were answered correctly in the pre-test, were answered incorrectly in the post-test. Some students said that their answers in the pre-test were based on memory of their work in Junior secondary school, and / or guesswork. Some questions merely asked for boxes to be ticked or one of two alternatives to be given. Students therefore may have produced correct answers by chance. This was often borne out in the interviews, when they were unable to explain their understanding. It is clear from the post-interview that some misconceptions were ironed out, but that others were resistant to change. Some students, e.g. 1, 2 and 3 were unable to make progress in their understanding of the topic. For the more able students, their understanding was extended within the module of lessons. They demonstrably learned how to measure current and voltage, some properties of electromagnets and about the behaviour of series and parallel circuits. There is some doubt that their understanding of the difference between current and voltage was clear. Giving the four learning strategies (class work, teacher explaining, computer work and practical work) points for a first, second, third or fourth choice for all the 6 students together produces an even split between computer work and practical (equally most preferred) and class work and teacher explaining (equally, but less preferred). As the post-interviews, which probed the students' incorrect test answers as well as their new understanding, included an element of instruction, it is likely that those students who came to some understanding saw the immediate value of one-to-one teacher explanation, and gave that as a preferred option (students 2 and 3).

The teacher-instigated SDI was planned to address a science topic over several lessons and incorporate an ICT approach, and had several foci for evaluation. These included consideration of the effectiveness and strategies of the teaching and learning, and issues of planning and class management. In this SDI, the focus was on overt teaching. Students were constrained in their learning, and there was relatively little off-task activity. Teacher A used a single ICT application - the simulation software Crocodile Clip. The ICT was exploited as a teaching tool, and A's main aim in using the simulation was to eliminate the "noise of practical work i.e. the variable results, difficulty in manipulating the equipment, etc. A was using ICT to make the conventional approach more effective, and approached the use of the simulated practical in much the same way as he did in the lab. There was no apparent pedagogical shift. The simulation was effective because students used the required design features for the tasks given to them by A.. The learning feature was that of replication of the practical lab-based scenario. As the students worked on the simulation software, A helped individuals, as much trouble-shooting software and students' ability to use it as helping students with their understanding of science. The simulation was used to ""do a series of directed rather than investigative task. In this sense, the SDI was teacher-driven. A retained control of the learning and directed students' activities but was dismayed at the relative amount of off-task activity of which he was naturally unaware taking place as he worked with individuals.

Effective use of ICT often depends upon the established pedagogical practice and the use of ICT within it. Science is often presented to students in a rather sanitised way as a finished product, as

A said in his interview about "formulated" practical work as opposed to investigation. The use of ICT to replace this type of practical work removes some of the messiness of lab-based work, further sterilizing it. However ICT can be powerfully used in science as in other subjects to explore, develop, express and critically redraft ideas and concepts. Our focus on learning objectives per see shouldn't obscure importance of locus of control, management of learning skills required (by teacher and students), e.g. appropriate and inappropriate use of simulations; straight-jacketed learning vs. learning anarchy. ' -

In Nigeria, efforts should be made to provide equipment for the teaching of science. Most of our students even in higher institutions do not have access to computers. The use of multi-modal approach to the teaching and learning of science should be encouraged.

Some science teachers cannot even use the inter-net effectively not to talk of using the computer for teaching. There is the need to educate science teachers on how to effectively use computers for teaching.

Oriafo (1988), recommended that judicious selection and sequencing of content, coupled with appropriate individualization strategies should be more adopted critically in the teaching and learning of science and technology at all levels of education in Nigeria.

The use of information communication technology is one of the ways of stimulating the interest of students. It is more of practical work than theoretical. Teachers can use the internet as a medium for giving assignments to their students.

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