The place of information and communications technology (ICT) on learning in science: a constructivist perspective illustrated by the concept of energy

El lugar de la tecnología educativa en el aprendizaje de las ciencias: una perspectiva constructivista ilustrada por el concepto de energía

KEITH ROSS

Science Education, University of Gloucestershire; School of Education, Francis Close Hall, Swindon Road, Cheltenham GL50 4AZ, UK, e-mail: kross@glos.ac.uk

Abstract.

Cohorts of UK primary trainee teachers on a B.Ed course (Graduate level teacher education) have used ICT (using computers and the network) to audit and assess their scientific ideas, and thereafter to build on or challenge these ideas. They have all achieved a science grade at school aged 16 equivalent to a C at GCSE, but few have studied science beyond the age of 16. This paper reports research into their ideas about energy and shows how the use of a tailored multimedia resource, linked with assessment based on concept mapping and learning logs, has been able to challenge some of their naive ideas. Implications for practice at primary and early secondary school (ages 7 to 14) are suggested.

Key Words: *science education; constructivist learning; energy; information technology*

Resumen

Muchos maestros en el Reino Unido utilizan la tecnología educativa (computadores e Internet) para intervenir y evaluar sus ideas científicas, y después de esto construir o desafiar estas ideas. Ellos lograron una calidad de la ciencia en la escuela para edades entre 16 años, pero poco han estudiado la ciencia para la escuela de edad mayor de 16, Este artículo informa la investigación en las ideas de maestros sobre la energía y muestras cómo el uso de los recursos multimedia, unidos con métodos de evaluación con mapas conceptuales y logros, se puede desafiar algunas de sus ideas iniciales. Se sugieren también algunas implicaciones para la práctica educativa de alumnos de edades de 7 a 14 .

Palabras clave*: educación en ciencias; aprendizaje constructivista; energía; tecnología educativa*

INTRODUCTION - THE SCIENCE OF ENVIRONMENTAL ISSUES

We have found that our primary Initial Teacher Education (ITE) students have many alternative conceptions about the scientific ideas including those that underpin an understanding of environmental issues. To improve their subject knowledge all first year primary BEd students do a science module, *The Science of Environmental Issues.*

The module addresses the alternative scientific conceptions many of the students hold (Driver et al 1994), but sets the science in a meaningful and realistic context.

Students come to us with a minimum of double 'C' in GCSE science. This UK school examination grade puts them in the upper half in terms of science achievement at aged 16. Many of us are unhappy with this as a prerequisite for entry to teacher education (it may be suitable for a transmission model of teacher training, but not suitable for ITE). A journal report by a UK chief examiner in the public awareness of science came to the same conclusion (Hughes, 1996). Analysis of our pre-module test and student learning logs confirms this view - our students come with many naïve conceptions about the way the world functions. For example a third of the cohort of 70 students thought that atoms were destroyed when fuels burnt. What sense would such students make of greenhouse gas emissions, or lead pollution from cars? Do they imagine that petrol gets 'used up' and everything 'burns away'?

The module occupies a tenth of the students' year one programme. The 6 units cover much of the UK Science National Curriculum: Matter (pollution, resource management and waste), Genetics (genetic engineering), Atmosphere (greenhouse effect, ozone depletion and acid rain), Biodiversity (habitat loss and evolution), Energy (the fuel crisis) and Radioactivity (concerns about the nuclear industry).

All students attend a lead lecture for each unit but because not all students have the same naïve conceptions in the same areas, students can attend additional tutor-led workshops for some of the 6 units but should cope with supported self study for the others. It was to provide this flexibility that led to the writing of the original self-study workbook which we later developed into a CDrom (Ross and Lakin, 1996, 1998). We administer a pre-module test, which helps students selected which units they will do by self study.

The research described here evaluates the effectiveness of this approach to supporting subject study in science, in particular it examines the use of ICT through the computer administered test, and the CDrom support we offer. We use the context of students' understanding of energy as a theme to illustrate and evaluate the approach and this leads to some implications for teaching about energy and about the use of ICT at primary and early secondary school (ages 7-14)

ASSESSMENT BY COMPUTER-MARKED PRE AND POST TEST

Philip Sadler of the Science Media Group at the Harvard Smithsonian Center for Astrophysics USA chose to publish his research findings in TV format, because written accounts, traditionally used for reporting academic research, were being ignored (Shapiro et al. 1997). Their research suggests that some college science courses confuse students so they do less well on a post-test than a pre-test. This is a well-documented area of study, pioneered by the researchers reviewed in Driver *et al* (1994) and which led to our use of a constructivist approach to teaching and learning. (Ross 1999, Ross et al 2000 and Asoko 2003). We have developed a 150 question multiple choice test using QM-Perception software which is used to audit students' initial ideas. The distractors are based on known misconceptions, and the test questions have been modified as a result of our own research into students' ideas, obtained from their learning logs and concept maps (see below). At the end of the course we re-administer the pre-module test, to assess the changes in students' ideas. These data are validated by examination of learning logs written by students which document perceived changes to their ideas, and their concept maps for each unit which portray their understanding of the major links between the main ideas we develop. The data used here refer to a cohort of 70 year one trainee teachers in semester 2 in 2001.

ASSESSMENT BY LEARNING LOGS AND CONCEPT MAPS

Students see assessment as a summative activity, and are interested mainly in their grade. This is not universally true, but it is close to the truth - all that effort tutors put into writing comments on students' work counts for little - and the further away from the submission date is the date they receive their grade and comments, the less they learn from it - it is over, it's in the past. In the case of examinations, where students do not see their scripts again, we cannot even make such evaluative comments to individuals.

The assessment system described here allows students to get immediate feedback from their assignments, and allows them to respond to tutor comments. The *learning process* is assessed, rather than the product, but we do get a summative grade at the end.

Use of concept maps and learning logs

Students have to write a learning log, covering no more than 1 side of A4 for each unit. They focus on the sections that were new to them, or that they struggled with, or in which they have gained new insights. The learning log allows them to translate ideas from the unit into something that makes sense to them. In addition they construct concept maps to show how one idea is linked to another. The essence is that it is their own attempt to make meaning The map and log are submitted a week after each unit is completed, and students get feedback from the tutor a week later in the form of star comments and a provisional grade. Figure one shows part of a log, with tutor annotations. This immediate feedback is important. Students must respond to the numbered tutor comments before re-submitting all 6 logs as their summative assessment of the module. The provisional marks can be modified up or down depending on the response made by the student to the numbered comments.

Misconceptions remain. It is clear from their logs that some ideas are not properly understood. We examine some of these in the examples relating to energy below. If these errors were made in an examination, or even an end of module assignment, students would remain in ignorance of their misconceptions. Many would have to be content to use half remembered ideas to answer an exam question or do an assignment. Without proper understanding they are likely to forget it all soon after submitting the assignment or sitting the examination. Tutor feedback is too late at this stage and it is understandable if they ignore it.

Our evidence from their logs and the increased scores on their computer-administered audit is that some conceptual progress is made during our science module. Whether this is due to self-study using the multimedia package, self-study of the workbook, or from ideas gained from the lead lecture and workshops is impossible to say, though they all embody a conceptual learning approach.

Below I use students' developing ideas about energy to illustrate the way ICT supports their learning. Insights from this have some important implications for teaching at ages 7-14 which I explore at the end of this paper.

TRAINEE TEACHERS' INITIAL IDEAS ABOUT ENERGY

Introduction

Two major confusions are tackled in this unit. The first is the confusion between the first and second laws of thermodynamics. The idea that energy can be transferred to different 'forms' but the number of joules is conserved (first law) conflicts with the everyday view that energy gets used up. This idea is more closely linked with the second law which says that energy becomes progressively degraded and spread out – and in this sense its usefulness does get used up – energy becomes less and less useful (Ross 1988)

The second major problem relates to fuels and food. Most people say that fuels and food *contain* energy, which is misleading (Ross 1993). Fuels must combine with oxygen if energy to be released and it is the system of reactants (the fuel-oxygen system) that stores the chemical energy, rather than picking out one reactant. Saying fuels *contain* energy is like saying the zinc rod of a dry cell contains energy. Both reactants are needed for the reaction, and energy is transferred as a result of the chemical change.

The unit also explored two other confusions relating to energy, *heat and temperature*, and the terms relating to *electricity*, before examining the sustainability of the way we 'use' energy. We introduce the term *replenishable* energy sources, rather than *renewable*, to describe those sources, mostly fuelled by the sun, which are (or can be) replenished year by year.

'Using' energy

The idea that joules are never lost, but they become progressively useless as they scatter as waste heat was dealt with in the multimedia version by animation of 'Sankey' diagrams which look at the origin and fate of energy 'used' to fuel various appliances. The unit tries to show that it is its *usefulness* that is used up as energy degrades to waste heat. (Ross, 1988). The whole idea is neatly summarised by figure two, animated in the multimedia package, and by figure three showing that although energy is not used up but becomes useless. The word energy has these two meanings, and we need to clarify if we are talking about joules (not used up) or usefulness (which is used up). Common definitions of energy 'ability to do work' apply only to high-grade sources of energy and have a meaning closely related to the second law.

Two questions in the audit probed students' understanding of this distinction. One asked about the energy transferred from burning fuel during a car and the other about the usefulness of the energy from respiring food during a bike journey 'yesterday'. There was a significant (at .01) drop in those saying energy was used up (14% to 2%, n=70), but no significant change in appreciating that usefulness had gone (42% to 48%). In a simpler question about energy transfers when an electric light bulb was used, those saying that 100% of the incoming joules were transferred to light and heat increased from 56% to 85%.

Further evidence of a change in understanding comes from students' learning logs, written as part of the coursework assessment. *"I was always confused by the word energy. I always knew it was useful but could never explain precisely to anyone what it is. I now realise that energy can be described in two ways ... that its usefulness can be used up ... yet the amount of energy remains the same.*"

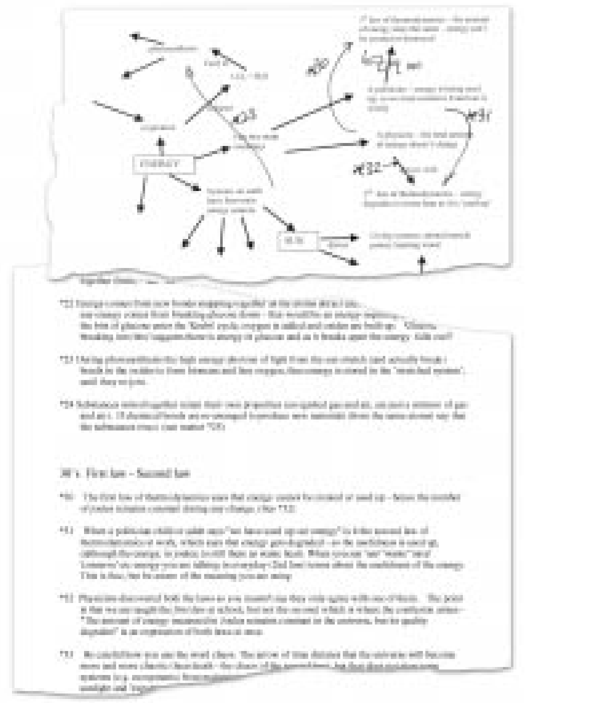

Figure 1: An example of a student's concept map for Unit 5: Energy, with a section of the related numbered tutor's comments, showing how they are used.

Energy from burning fuels and respiring food

During the energy unit we show that transfer of energy from fuel and food is always (with the exception of anaerobic respiration) associated with the need for oxygen. There is a long sequence in our multimedia version beginning with screens showing that burning needs *air and fuel* ending with a video clip of a match being struck in a bell jar containing natural gas – no explosion, no flame, just smoke as the match fails to light.. It confronts a major misconception that fuels 'contain' energy - students tend to think that when fuels burn only energy (and some 'waste gas' or ash) is left. The idea is illustrated at an atomic level by an animation of the chemical change as molecules of methane gas and oxygen form carbon dioxide and water. Energy, from the stuck match, is supplied to break bonds in methane and oxygen. As new bonds are made during combination the amount of energy transferred is calculated. We try to show that fuels, on their own, do not *contain* energy, but that it is the formation of new strong bonds during the reaction with oxygen, that allows energy to be transferred. This point re-occurs in other parts of the CD-rom, especially in sequences relating to photosynthesis and respiration.

Students' ideas about 'energy in fuels' were probed by two sorts of question – some relating to matter some to energy.

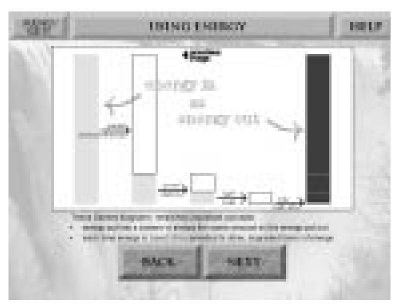

Figure 2. Screenshot from the Energy Unit of *Science Issues and the National Curriculum* showing that although the number of joules doesn't change during energy transfer, its usefulness gets less and less. The Lighter coloured blocks on the left represent useful (useable) energy, and the darker blocks on the right represent waste heat.

Matter probes: A strong impression build up in our everyday experiences that burning is a destructive process, and this leads to about a third of students (n=120) coming to us thinking that atoms were destroyed during burning – their idea is that energy is released from fuels leaving only a little exhaust gas. There was an increase from 16% to 65% who chose to say the exhaust gases were much heavier than the petrol because of the added oxygen (previously they said it was much lighter - 44% down to 4%). When we asked them about respiration, although the course taught them that atoms are conserved, we seemed less successful in getting them to distinguish between matter and energy:

Consider the *material* (stuff, matter, atoms...) in our food that enters our blood and which we have *used as a fuel*. Which of the following describes how does this *material* leaves our body? (Chose true or false for each alternative)

· The atoms are all used up and only energy is left.
  Chosen as true by 37% at start and by 2% at end

· We breathe a lot of it out as carbon dioxide and water vapour. (9% to 23% true)

· It comes out as energy, e.g. movement and heat. (70% to 77% true)

This shift from a destructive to a constructive view of burning was confirmed by two other multiple choice questions and by comments from one in three of the trainee teachers in their learning logs: "I had never realised that these atoms could not be destroyed, and that they remain after the material had been destroyed. The idea that burning is a constructive process [adding oxygen atoms] was also new to me, but became obvious after the explanations." "I found the principles of burning very enlightening. The constructive process of oxygen forming oxides and increasing weight now seems very obvious."

Energy probes. If students have a destructive view of burning they are likely to say that fuels *contain* energy, which is released during burning. This question asked if these statements about energy and fuel were true or false:

· When fuels burn the energy trapped in them is released (59% initially to 26% at end) (n=120)

· The energy is not in the fuel itself, but is associated with both the fuel and oxygen (71% to 85%)

· Fuels contain energy-rich bonds which release energy when the bonds break (52% to 37%)

· Energy is released when new bonds are formed. This happens during burning (59% to 70%)

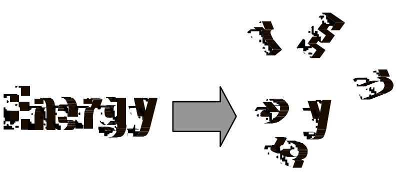

Figure 3: Word play showing the degradation of energy from useful to useless, but no loss of joules (from unit 5 Energy of Ross & Lakin 1998)

These results suggest that it is hard to move away from the 'energy in fuel' and to accept the bond-making process as the energy transfer step. The *energy-rich bond* is a concept cemented into many biologists' repertoire. It has a grain of truth in it, but few people see these bonds as weak but still *requiring* some energy to break. It is the making of new stronger bonds to replace these *energy-rich bonds* that allows energy to be transferred for use by the cell. On this basis molecular oxygen, with its weak bonds and high reactivity, should be classed as an *energy rich* substance – but not the food or fuel.

Replenishable energy

The energy unit tries to get across the idea that although the number of joules doesn't change during energy transfer, the energy loses its usefulness. When we talk of an energy shortage, or crisis, it is a shortage of high-grade useable sources that is meant. The unit stresses the importance of the sun as supplying energy to drive life and climate. The unit illustrates the idea that the earth receives a daily ration of high-grade sunlight that is dissipated back to the universe as low-grade waste heat. (see fig 4 for a screen shot). Without a constant input of high-grade energy the life climate and industrial system on earth would stop. We show that industry is mostly reliant on non-replenishable sources of energy from burning fossil fuels. We point out subsistence economies, common in less developed countries, and everywhere before the industrial revolution, are fuelled by replenishable sunlight through biofuels, animal muscle power, wind and waterpower. Some civilisations did not replant to replace grazing or wood fuel reserves, and in these circumstances biofuel and muscle power are not replenished, though still replenishable.

There was a slight but significant increase in students' awareness of these ideas:

They were asked to choose those systems that were powered by replenishable resources and a related question to decide which were powered directly or indirectly from the sun (n=120)

Hydro-electricity (83% to 91% replenishable, 44% to 60% solar driven)

Sailing boat (84% to 94% replenishable) windmill (44% to 60% solar drive)

Wood-fuel stove (36% to 51% replenishable, 47% to 65% solar driven)

Horse-drawn cart (71% to 82% replenishable) Bicycle and rider (52% to 77% solar driven)

But there was little change in those who saw coal and gas as inexhaustible:

Coal-fired steam engine (17% to 15% not significant)

Natural gas hot air balloon (45% to 34%)

There is clearly a difference in perception between climate and living systems. The climate is perceived as providing 'renewable' energy but students do not so readily appreciate that it is 'fuelled' by the sun. Although they think that wood fuel is fuelled by the sun, students are less ready to class it as *replenishable* – this is understandable since it depends on whether the fuel comes from sustainable forestry or not. Muscle-power is more easily seen as *replenishable* than being *solar powered*.

SCIENCE ISSUES AND THE NATIONAL CURRICULUM

In order to make the multimedia resource available to users other than our own B.Ed students, and to provide support across the curriculum we have added four new units (Agriculture, Health, the Home and Transport) and also put an index linked to the UK National Curriculum at the front, to allow students to access the CD through traditional science topics as well as through the 10 issues. (Ross *et al* 2002)

The multimedia resource is still based on two principles

· it identifies the main misconceptions preventing conceptual understanding in science

· it sets the science concepts into a relevant context for the student – 6 environmental and 4 everyday life issues.

We have recognised the importance of conceptual learning by making the screens of this CDrom as interactive as possible. Interactivity is needed firstly to identify the conceptual base from where the student starts. This is done mainly by multiple-choice questions which then respond to different ideas from the learner. Interactivity is also needed to help the learner take ownership of ideas. Opportunity is provided for learners to use and apply new ways of thinking for example by use of drag and drop and games. Although we tried to reduce the amount of text wherever possible, text is still an effective way of giving information. Because of the difficulties of reading from screen we broke text up into manageable chunks and kept the language clear and direct. We also made text active, wherever possible: if students have to perform an action to get an item of information, they are more likely to understand and retain it (Terrett & Wood, 1994).

Figure 4:. Screenshot from the Energy Unit of *Science Issues and the National Curriculum* showing that although the energy arriving on and leaving the earth is approximately the same, assuming the earth maintains its constant temperature, it comes in as high grade useful sunlight and leaves as waste heat. (energy input also comes from the Earth's hot core, which is neglected in this diagram for simplicity).

One of the recurrent problems associated with multimedia courseware is that of navigation. Most of us know how to find information in a book - how to navigate through it, how to find specific information by use of the contents page or the index, how to close it (McAteer & Shaw, 1995). On a computer, however, much of this information is missing, or hidden, making it easy for the user to get "lost in hyperspace" after following only a handful of links between topics (Deegan et al, 1992). For this reason, we felt it important to design the structure of the package so that students can explore freely *within* sections, but are unable to jump *between* sections except by returning to menu pages.

Most multimedia software for education is written by software authors. They can be very elaborate and full of gimmicks but may fail to allow the learner to interact fully with them. We were fortunate to have Keith Brooke as our programmer, a science fiction writer with a degree in ecology. The resource was written with a learning philosophy and an understanding of conceptual change in mind, even though we may have left out some of the singing and dancing that makes some multimedia resources superficially attractive.

IMPLICATIONS FOR TEACHING AT AGES 7-14

We have used ICT to support the learning of trainee teachers, both through a computer-based audit of their conceptual understanding of science, and through the development of a multimedia resource which supports their conceptual learning. In this final section I explore implications for teaching and learning in school, exemplified by: the use of ICT and for developing children's ideas about matter and energy.

Primary to secondary transfer and ideas about matter and Energy

Galton (2003) explores the difficult transition between year 6 (UK primary) and year 7 (UK secondary) at age about 11. It is easy for secondary teachers to adopt a 'fresh start' as pupils enter year 7 from a range of school and home experiences. However we have seen how firmly held are the ideas of some trainee teachers, unaffected by their science courses in secondary school, and even failing to construct new meaning in their teacher training course, when the misconceptions are identified and exposed. Ideas about energy develop before children enter primary school. The word *energy* is commonly used by 5 year olds, and the idea that burning destroys things, but produces heat is again common knowledge. Later on it develops a meaning closer to the second law concept of 'free energy': the ability to do something – to make something happen. Clearly the idea of energy measured in *Joules* which cannot be used up is contrary to our common beliefs. Osborne, (2003) points out the way in which words used in public interactions and popular press are used in different ways in school science laboratories. Children come to secondary school with an everyday view of how the world works, and we need to take this into account when we start teaching them 'real' science in the secondary school.

In the upper primary school we need to establish the idea that matter changes, but is not destroyed. Children begin to see gases as real matter, even though it is so spread out. Careful attention needs to be paid to the products of combustion and respiration and to the need for both to have a supply of air. Children can time candles burning under different sized jars, and see the condensation. They can monitor their heart rate and breathing during and after exercise to show that there is a link between energy and breathing.

At KS3 ideas of matter and energy can be separated. Children can account for the materials during changes such as burning, from an atomic point of view. They can use models to show that fuels join with oxygen producing (mostly) gases. We can replace word and symbol equations with animated models to show that there is no loss of atoms. We can take their growing ideas about energy being 'used up' to show that waste heat is produced when things happen. We can begin to show that if we add up all the waste heat we get the same amount of energy we started with, except that it is now useless. Thus the word *energy* becomes two concepts – Joules that remain, and 'free energy' or usefulness which is used up.

ICT in whole-class mode

Baggot et al (2003) show how ICT can support and enhance learning in school. Without this enhancement it is of no value, but just a drain on our time and resources. There is only so much that can be demonstrated in class and activities that children can safely do themselves are even fewer. Often such demonstrations and practical activities take too long to set up and are too complex for the pupils to make meaning from them. They become a recipe to follow, and pupils dutifully record 'results and conclusion' in their books, with little clue as to what they have done and why. (Ross et al 2000 ch. 1).

A CD-rom with a set of simple analogies and video clips could be used to illustrate a point in a few seconds:

> Pupils burn candles, we animate the reaction, not with a meaningless word equation:
>
> Wax + air = carbon dioxide + water
>
> but with the carbon and hydrogen atoms of the wax and oxygen molecules being broken apart in the heat, and rebonding to form molecules of water and carbon dioxide. Pupils can see that there is no creation o destruction of matter, and that energy becomes available through formation of new strong bonds.
>
> Pupils see a video clip of a car driving by and a horse running. This stimulates discussion of the similarities of respiration and combustion.

CONCLUSIONS

Self-study material is widely available on line in almost every branch of knowledge. How many of these are carefully crafted museums but with no inbuilt learning strategy? We cannot expect pupils to discover the ideas of science by themselves. It took mankind centuries to do this. Those learning packages that do have a learning path often have no learning philosophy. They don't take account of the learner's prior conceptions. This can mean that naïve ideas are simply reinforced rather than challenged. We need to test learners' ideas and allow the learning package to respond, either to build on sound ideas or to show where they are limited, and to challenge their broader application.

We cannot expect others to create these learning packages for us. We have to become involved intimately with those creating the software. Whatever success we have made with our CD-rom described here (Ross 2002), it has been largely due to the way it has been informed by our own understanding of conceptual problems of our students, and the editorial control we have had in its development.

BIBLIOGRAPHY

Asoko, H. (2003) Developing Conceptual Understanding in Primary Science. *Cambridge Journal of Education* **32** (2) pp153-164.

Baggot la Velle, L; McFarlane, A., Brawn, R. (2003) Knowledge transformation through education; a case study in teacher-driven curriculum developmen. British Journal of Educational Technology, vol. 34, N° 2, pp183-199.

Deegan, M., Timbrell, N. & Warren, L. (1992) *Hypermedia in the Humanities*. Sheffield: CVCP/USDU.

Driver, R. (1994) *Making Sense of Secondary Science*. London: Routledge.
http://www.learner.org/resources/resource.html?uid=26 (accessed October 16, 2001)

Galton. M. (2003) Continuity and progression in Science Teaching at Key Stages 2 and 3. *Cambridge Journal of Education* **32** (2) pp 249-266.

Hughes P.,(1996) Failing the comprehension test. *New Scientist*. vol**151** No2046 page 45 (7th September 1996)

Hughes, P. (1996) Failing the comprehension test, *New Scientist*, vol. 151, No. 2046, p. 45.

Littledyke, M and Huxford, L. (1999). Teaching the Primary Curriculum for Constructive Learning. London: David Fulton

McAteer, E. & Shaw, R. (1995) *The Design of Multimedia Learning Programs*. Glasgow: EMASHE Group, University of Glasgow.

Osborne, J. (2003) Science without literacy a ship without a sail. *Cambridge Journal of Education* **32** (2) pp 203-218

Ross, K. & Lakin, L. (1996) *The Science of Environmental Issues*. Cheltenham: Cheltenham and Gloucester College of Higher Education.

Ross, K., Lakin, L., Littledyke, M. and Burch, G. (2002) CD-ROM: *Science Issues and the National Curriculum*. Cheltenham: University of Gloucestershire. Details from http://www.glos.ac.uk/science-issues

Ross, K. A (1999) Science: Brenda grapples with the properties of a mern. Chapter 6 in Littledyke and Huxford

Ross, K.A. (1988) Matter Scatter and Energy Anarchy – or the Second Law of Thermodynamics is simply common sense. *School Science Review*, **69** (248) pp 438-445

Ross, K.A. (1993) There is no energy in food and fuels – but they do have fuel value. *School Science Review*, **75** (271) pp 39-47

Ross, K.A., Lakin E. and Callaghan, P. (2000) Teaching Secondary Science. London: David Fulton

Shapiro, I., C. Whitney, P. Sadler, M. Schneps. (1997). Harvard-Smithsonian Center for Astrophysics, Science Education Department, Media Group, [online] URL:
http://www.learner.org/resources/resource.html?uid=26 (accessed September 30 2003)

Terrett, M. & Wood, B. (1994) *Guidelines for Multimedia Courseware Design*. Nottingham: CAL Group, University of Nottingham.

Received 30.09.2003, Approved 11.03.2004