Educational research on the use of ICT in science teaching – a selection of abstracts and further sources

Introduction

This document presents a selection of research on the use of ICT in science teaching. Rather than being an exhaustive literature review, the collection of abstracts and references should be seen as a starting point for those interested in the topic. References for around 70 documents are presented here, with abstracts for 10 key studies.

The literature is drawn from both the UK and other countries, with the majority of studies focusing on the secondary sector. Both primary research and literature reviews are represented. The research covers both science teaching as a whole and discrete subjects within science. Similarly, some of the studies discuss ICT in general while others consider specific technologies, such as simulations or data-logging. The literature also covers the pedagogical and organisational issues associated with the integration of ICT in science teaching.

Becta’s Evidence and Research team welcomes discussion on this topic through the ICT Research Network, and suggestions for further additions to this bibliography.

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This study assesses the extent to which ICT contributes to quality in learning in science at Key Stage 3. The author considers the meaning of quality in the context of science education and identifies some of the indicators of quality. Drawing on data from tests, interviews and observations, the study examines how ICT affects pupils’ understanding, their motivation and use of learning strategies, their mental engagement and the context for learning. Results suggest that ICT can enhance the quality of learning where its use is tailored to lesson objectives and the needs of pupils. In conclusion, the author presents a model for the possible use of ICT to increase the quality of learning in science. *(UK)*

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This study investigates the impact of a biology simulation 'The Growth Curve of Microorganisms' on high school students’ academic achievement and their science process skills. The study focuses on the relations between academic achievement, mastery of process skills, gender and cognitive stages. The findings indicate that the achievement of students using the simulation was higher than those not using the simulation, with girls achieving equally with boys. The simulation was found to benefit students with low reasoning abilities in particular, enabling them to cope with learning scientific concepts and principles which require high cognitive skills. *(Israel)*

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This paper looks at a case study of the initial stages of the development of the effective use of ICT in science education. Building on research and development work from the ICT strand of the Teaching and Learning in the Information Age Project, the paper reviews the issues relating to the transformations of teachers’ knowledge of science into effective teaching through ICT. The authors discuss the development of ICT use in science and illustrate current use in UK schools. A theoretical framework of teachers’ knowledge and pedagogical reasoning in ICT in science is then presented as the basis for the curriculum research and redevelopment that the case study involves. The authors describe and discuss the findings from the case study and offer some tentative conclusions on how ICT might enable effective knowledge transformation in science. (UK)

This paper considers two perspectives on the relationship between the science curriculum and the potential of ICT in science education: the first perspective is based on the current English secondary science curriculum, while the second looks at how the role of ICT might be developed if the curriculum were to emphasise scientific reasoning rather than the practice of empirical science. The paper focuses on the use of ICT to support or replace practical work and the use of multimedia or the internet as a tool for scientific reasoning. The authors argue that using ICT either as a tool in a practical investigation or as a substitute for the laboratory-based elements of an investigation can aid theoretical understanding. They also comment on the role of the internet and electronic communications in developing scientific literacy and an understanding of authentic science. In conclusion, the authors propose a curriculum model which has a balance of empirical science and critical science, each supported by the appropriate use of ICT. (UK)

This article presents data from a case study of one class participating in the Kids as Global Scientists (KGS) Program, a project which engages students in the study of atmospheric science through the use of authentic images and online communication. The authors examine the motivational effect of KGS through an in-depth study of six students representing three levels of motivation, looking at how the students view science learning and the use of technology both before and after participating in the project. Findings indicate that students made significant gains in weather content knowledge (as measured by written assessments) and showed a high level of motivation. The authors conclude by identifying the key characteristics for creating a learning environment that promotes both motivation and achievement. (US)

http://www.nestafuturelab.org/research/reviews/psi01.htm
This review considers the development of primary science since it became a compulsory, core subject in England and Wales in 1989 and examines the impact of ICT on its teaching and learning. The paper provides both an overview of research into children’s science learning and a critical evaluation of ways in which ICT is currently being used to promote good science teaching. In particular, it focuses on
the relation between ICT and four key areas of concern: the teacher’s role in constructivist learning; teachers’ subject knowledge; the balance between process skills and science content; the need for greater understanding and application of formative assessment. (UK)


This article surveys some of the benefits of the use of data-logging methods identified in the research literature. The author then examines the classroom implementation of data-logging through a small-scale qualitative study of the use of data-logging in UK secondary schools. He presents findings from interviews with five science teachers under four themes: teachers’ rationales for data-logging; obstacles to implementation; strategies for overcoming these obstacles; developing learning objectives. The author concludes that the potential contribution of data-logging to learning is considerable but its successful implementation depends on a number of factors, including the availability of resources, teachers’ skills, and opportunities to use data-logging in the curriculum. (UK)


This paper reviews the current state of science education, the impact of ICT use on the curriculum, pedagogy and learning, and the implications for future practice. The paper considers how ICT can be employed flexibly to support different curriculum goals and forms of pedagogy, and shows there are diverse ways of linking ICT use to existing classroom teaching, including supporting or replacing it. It is suggested, however, that transformative use of ICT in science is found only in isolated pockets as technology is not yet embedded in the culture and practice of many science teachers. The authors argue that the content-oriented National Curriculum has hindered the development of classroom use of ICT, but as the science curriculum moves towards a greater emphasis on scientific reasoning and analytical skills, they suggest there will be more opportunities for ICT to play a key role in science education. (UK)


The purpose of this study was to investigate the factors that influenced five middle school science teachers as they implemented and integrated calculator-based laboratory (CBL) probeware in the curriculum. The study involved empirical research with both qualitative and quantitative data, through interviews, questionnaires, anecdotal records and observations of teachers. The study presents a holistic view of the influences on the level of teacher technical proficiency with CBL probeware, level of actual use during integration into the curriculum, changes in pedagogy, changes in organisational culture, and curriculum transformation related to CBL probeware. The findings indicate that 80 per cent of participating teachers successfully integrated CBL probeware into their teaching. The study also identifies the contextual barriers to integration, including training in the use of the technology and pedagogical support. (US)

This paper presents the findings from a two-year study of the implementation of ICT in teacher education and school settings. Through surveys, interviews, visits and observations, the study examines four themes: teachers' knowledge and beliefs; computer use for instruction; hardware access; school support for technology use. Results indicate that teachers given identical training and equipment differed widely in how they implemented technology. The authors argue that these discrepancies result from teachers' existing practice and their beliefs about their school context. The authors conclude by considering the implications of the findings for ICT implementation, the evaluation of technology initiatives, and, in particular, for teacher education. (US)

Further sources


Summary table of research on the use of ICT in science

This summary table provides a quick reference guide to the main findings from selected documents of a literature search carried out by Becta in November 2003. It compliments the more detailed bibliography on ICT in science by identifying the key findings, age/level and sample size for each reference.

<table>
<thead>
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<th>Key findings</th>
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<th>Summary</th>
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<tr>
<td>• ICT offers particular opportunities to enhance learning by making more time available for predicting and searching for explanations</td>
<td>117 Key Stage 3 pupils</td>
<td>This study assesses the extent to which ICT contributes to quality in learning in science at Key Stage 3. The author considers the meaning of quality in the context of science education and identifies some of the indicators of quality. Drawing on data from tests, interviews and observations, the study examines how ICT affects pupils’ understanding, their motivation and use of learning strategies, their mental engagement and the context for learning. Results suggest that ICT can enhance the quality of learning where its use is tailored to lesson objectives and the needs of pupils. In conclusion, the author presents a model for the possible use of ICT to increase the quality of learning in science. <em>(UK)</em></td>
<td>Betts, S., (2003). Does the use of ICT affect quality in learning science at Key Stage 3? <em>Studies in Teaching and Learning</em>, pp. 9-17.</td>
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<td>• Pupils in the simulated learning environment exhibited complex and integrative reasoning</td>
<td>181 tenth grade pupils</td>
<td>This study investigates the impact of a biology simulation 'The Growth Curve of Microorganisms' on high school students’ academic achievement and their science process skills. The study focuses on the relations between academic achievement, mastery of process skills, gender and cognitive stages. The findings indicate that the achievement of students using the simulation was higher than those not using the simulation,</td>
<td>Huppert, J., <em>et al.</em>, (2002). Computer simulations in the high school: Students' cognitive stages, science process skills and academic achievement in microbiology. <em>International Journal of Science Education, 24</em> (8), pp. 803-821.</td>
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repetition of experiments which in turn aided understanding

with girls achieving equally with boys. The simulation was found to benefit students with low reasoning abilities in particular, enabling them to cope with learning scientific concepts and principles which require high cognitive skills. *(Israel)*

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<td>McFarlane, A., Sakellariou, S., (2002). The role of ICT in science education. <em>Cambridge Journal of Education, 32</em> (2), pp. 219-232.</td>
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<td>• Pupils made significant gains in scientific knowledge</td>
<td>This article presents data from a case study of one class participating in the Kids as Global Scientists (KGS) Program, a project which engages students in the study of atmospheric science through the use of authentic images and online communication. The authors examine the motivational effect of KGS, and identify the key characteristics for creating a learning environment that promotes both motivation and achievement. <em>(US)</em></td>
<td>Mistler-Jackson, M., Songer, N.B., (2000). Student motivation and internet technology: Are students empowered to learn science? <em>Journal of Research in Science Teaching, 37</em> (5), pp. 459-479.</td>
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<td>• There is a lack of research into how ICT can enhance...</td>
<td>This review considers the development of primary science since it became a compulsory,</td>
<td>Murphy, C., (2003). <em>Literature review in primary</em></td>
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pupils’ learning in primary science
- Systematic research is needed into the potential of specific applications of ICT
- Software designers need to work more closely with both children and teachers

core subject in England and Wales and examines the impact of ICT on its teaching and learning. The paper provides both an overview of research into children’s science learning and a critical evaluation of ways in which ICT is currently being used to promote good science teaching. It focuses on the relation between ICT and four key areas: the teacher’s role in constructivist learning; teachers’ subject knowledge; the balance between process skills and science content; the application of formative assessment. (UK)

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<td>Osborne, J., Hennessy, S., (2003). Literature review in science education and the role of ICT: Promise, problems and future directions. NESTA Futurelab Series, Bristol: NESTA Futurelab. <a href="http://www.nestafuturelab.org/research/reviews/psi01.htm">http://www.nestafuturelab.org/research/reviews/psi01.htm</a></td>
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<td>Wetzel, D.R., (2001). A Model for Pedagogical and Curricula Transformation for the Integration of Technology in Middle School Science. Paper presented at the Annual Meeting of the National Association for Research in</td>
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80 per cent of participating teachers successfully integrated CBL probeware into their teaching
- Barriers to the integration of the CBL probeware included: lack of time for training, lack of CBL resources, lack of
| Teachers given identical training and equipment differed widely in how they implemented technology. These discrepancies result from teachers’ existing practice and their beliefs about their school context |
| Five secondary school teachers |
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