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E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

ESRC Seminar Series

Educational Research and the Design of Interactive Media

Final report: Building Collaboration between Designers and Researchers

The contents of this document are based on a series of seminars conducted during 2003 and 2004, funded by the ESRC, that were coordinated by Lydia Plowman, University of Stirling. They were also sponsored by a number of organisations including Futurelab.
Each seminar was attended by researchers from universities, creators and managers of companies that make educational resources, and people engaged in policy making or representing Government agencies.

The seminars considered the main questions around specific themes and took place in different parts of the UK:

- Seminar 1: Identifying the issues, London (sponsored by the DfES)
- Seminar 2: Narrative, Coventry (sponsored by Becta)
- Seminar 3: Mobile technologies, Bristol (sponsored by Hewlett-Packard)
- Seminar 4: Play and learning, Edinburgh (sponsored by Scottish Executive)

Further information on these seminars can be found on the Futurelab website – **www.futurelab.org.uk/events/past/esrc_intro.htm**

This summary is based on a symposium at the CAL2005 conference in Bristol in April 2005, presented by Charles Crooke (University of Nottingham), Lydia Plowman (University of Stirling), Martin Owen (Futurelab) and Rosamund Sutherland (University of Bristol).
It was edited by Martin Owen and Lydia Plowman with contributions from Julie Cogill (Kings College, London) and Ros Sutherland and Federico Olivera (University of Bristol).

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Introduction

How can research on teaching and learning be used to improve the design of e-content? Designing e-learning resources requires a team with diverse talents but sometimes the educational aspects get overlooked. Although most people know it's likely to be beneficial to include knowledge about learning and teaching in their designs, it doesn't always happen. There are several reasons why designers might find this difficult:

- They don't know how to find out who the research experts are in the field they're interested in or how to make contact with them.
- They don't know how to find the relevant published research because it's often hidden away in journals that nobody's heard of and that are difficult to locate.
- If they find some research in the right area it's sometimes difficult to see its relevance or to interpret how it might be useful for the design process.

Even if those in the digital content industry find some useful research and identify somebody with expertise in the relevant aspects of teaching and learning, there are still barriers to involving them in the design process. This can be because:

- There is a lack of **communication** between researchers and industry. Different language and specialised terms may be used to describe areas in which both groups have an interest. But it's also because academic research tends to use its own jargon that can seem impenetrable to others.
- Different **timescales** can be a barrier to productive collaboration. Commercial companies and the education sector work to different rhythms and schedules. A design process that is informed by user studies can be very time-consuming as it needs to go through a number of cycles.
- Small companies don't always have the **budgets** for collaboration with educational researchers.

Designers sometimes make a case for involving a researcher in the team but can meet resistance from sales or finance departments which believe that various design inputs are inappropriate, not marketable or too expensive to implement. It is also difficult for them to identify the point in the design cycle at which input is likely to be most valuable and have most impact. So getting input from researchers seems a bit of a luxury because it can add to costs and lengthen timescales.

The case studies in this guide demonstrate that including research on teaching and learning can make a difference to the design process. This should lead to increased sales because it leads to a better product and happier customers – the students and teachers who will use the product.

The design focus here is on e-learning content for delivery through interactive media such as the web, CD-Roms or mobile technologies for children aged 5-16. Some of the questions that will be considered in the case studies include:

- At which point(s) in the design cycle is research input likely to be most valuable and have most impact?
- How can teachers and learners be included in the design process?
- How generalisable are research findings?
- Which should come first – the overall design or the learning content?
- To what extent does content have to link to the curriculum to have educational value?
- How marketable is educational value?

What follows in this document is a sharing of perspectives, some advice for future action and five case studies illustrating a diverse range of collaborations – small enterprises, a large-scale international company, the Science Museum, BEAM Technology, Nelson-Thornes, and a research team working with a local media company.

Research from university researchers' perspective

The development of new knowledge and understanding is a key motivation for university researchers. This may arise from developing new products or studying educational change. These changes are viewed in two ways. First there is a formative evaluation. Formative evaluation takes place during the design and implementation of a change. The purpose is to improve the change as it's taking place. This research would be undertaken in conjunction with the change agent (designer, policy maker etc) with frequent feedback to help the change agent steer their activity. Summative evaluation judges how effective a change has been. It is a study of the effects of a change that has been carried out – some of which may have been unintended – and may be of benefit for future activity or future policy.

Research in learning with technology has all three kinds of research: inventing new ideas and methods and inventing theories of how people learn; working through an iterative try-and-reflect development process in developing something new; and providing evidence of the effects of what has been done.

There is a clear overlap here in the needs, roles and areas of interest of designers and the education community, as illustrated in Diagram 1. One circle shows the foundation skills and conceptual structures that designers use and the other circle shows the foundation skills and conceptual structures of education researchers and teachers. What may make life frustrating for the designer is that researchers do not view the concepts in their circle as straightforward and there is nothing that someone would not contest. This uncertainty is what makes researchers want to ask the questions.

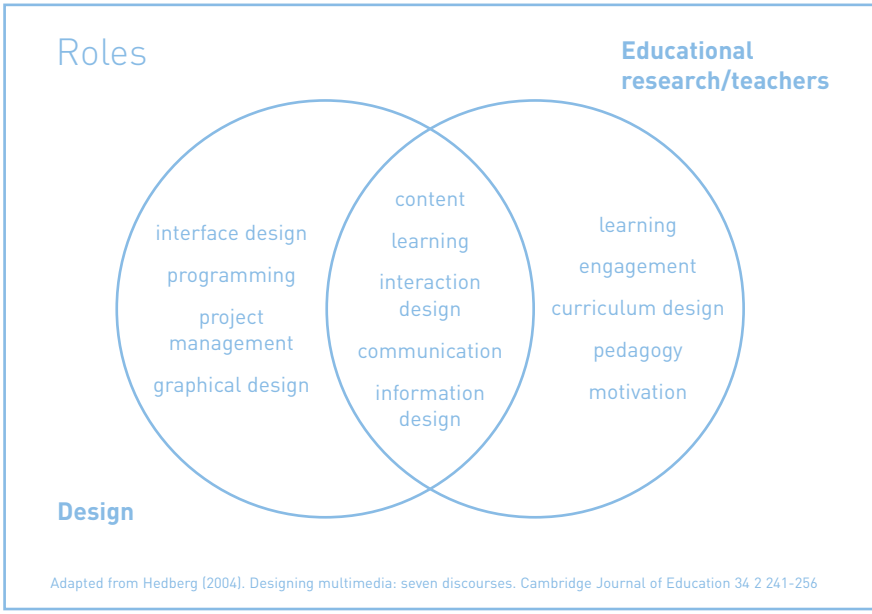


Diagram 1

Working with learners and teachers

A key area for researchers in interactive learning is working with teachers and learners. It is in this area that there is a clear opportunity for the design and research communities to work together. This in itself presents choices such as how do you, as a designer, want to work with your users? What kinds of users should be involved? Are they experienced or inexperienced? Does their age influence the extent to which they can voice their opinions?

A key benefit for designers who choose to work with researchers is that they have access to an existing body of knowledge and theories on which to base design. It is fair to say that this knowledge is not in a form that is easily accessible, because it is written in a language that the researcher uses to be able to express ideas to other researchers, and the material that carries this body of knowledge is not easily found outside of university libraries – even if it is online it requires expensive subscription.

The strength of having this body of knowledge and theoretical frameworks is that it helps formulate the questions: Why are you designing this? What problems are you trying to solve? What effects do you think you are going to have on the learner? What methods can we apply to uncover what is happening?

Exposing the design ideas to teachers and learners early in the development will help because it will uncover questions like 'If I am going to use this resource what else needs to happen?' and 'Can this work in the way my school is organised?'

Some viewpoints from industry

As will be seen in the case studies included here, there is no single typical designer's need or viewpoint. However, at the seminars, concerns were expressed by the industry attendees:

- It is not easy to find research that is relevant – journals, for instance, are expensive and they are located in university libraries seldom visited by designers.
- The language and forms of publication of research make it difficult to understand and difficult to use.
- Industry is inventive, creative and dynamic – new solutions may not have the existing research to support the idea – thus following inspiration can be more effective than drawing on proven theories.
- The timescales that research takes – how long it takes to get funding, how long it takes to be completed and then how long it takes to get published – need to be addressed.
- Researchers may need to adapt or develop methods that help industry and recognise that, for the commercial partner, sustaining their business is the priority.
- Intellectual Property is an issue and may lead to a conflict of interest. An enterprise may need to protect commercial interests whereas academics will want to publish their results.

Case study:
a SME multimedia company

AtticMedia are collaborating with Futurelab to create some innovative practices in modern foreign language teaching, whereby a language game is played both in Spain (in English) and in the UK (in Spanish) by upper primary age children and is then supported by video-conference interactions. The project is called Iya-Ola. The company has some experience in making educational materials and is clearly able to find and recruit teachers to help author interactive curriculum materials. However this project takes both the company and teachers into uncharted territory.

Futurelab helped to identify important trends by using practitioners and advisors with knowledge of existing practice in video-conferencing in foreign language teaching and in forming classroom-to-classroom links. Futurelab's Literature Review in ICT and Learning in Modern Foreign Languages also enabled the company to clarify thoughts about the methodology.

Together the team were able to identify some research questions from the curriculum development of learning research objectives. Through the development of the Iya-Ola prototype, Futurelab and the project partners are looking to answer the following questions:

- What language vocabulary, constructs and games structures are appropriate for learners at this age (upper primary)?
- Does Iya-Ola offer learners effective practice in their language skills and is it sufficiently challenging?
- How are learners best prepared for collaboration?
- Does the system actually support collaboration?
- Is collaboration best viewed as a peer-to-peer, a class-to-class or a group-to-group interaction?
- What other resources and preparation are required before the use of Iya-Ola?
- What kind of classroom settings and arrangements are appropriate for using the game?
- What features can sustain collaboration beyond the game?

The project has used a university specialist in primary school modern language learning as a lead researcher to assist in the research into these objectives. Over 12 months there are periods when the university researcher works with students in both the UK and in Spain to establish the necessary links and to gather the evidence needed to illuminate the questions using a variety of research techniques.

This is not a full-time research project for the university researcher. It is managed and arranged around their activity and the pace of development of the interactive material. For example trips to Spain to gather evidence have to fit into other scheduled visits. It requires flexibility from all sides.

Case study:
a large multinational

A large educational toy company has many research needs which span several timescales. The company engages in a number of collaborative international projects to support their innovation and has several internal research facilities covering materials science, production processes, product design, systems engineering, market research and product testing with children. The company's founder has been a benefactor of a learning technology team in a major US interactive media research centre in a prestigious US university - and the company has benefited from this interaction, leading to product ideas.

The timescales for internal research vary depending on the company's needs:

- **A lab that provides vision:** 5-8 years horizon – identifying trends. These are not just toy industry trends but also trends in materials science and the plastic materials from which the products are made.
- **Concept lab:** 3 years horizon – suggestions about what could be the next product on the market.
- **Technology procurement:** 1-2 year horizon – new hardware solutions for actual projects. This involves finding new components that make new products possible, as well as those required for manufacture.
- **Virtual innovation:** 1-2 year horizon – virtual building and combination products - the use of new technologies to imagine potential projects and test the reactions of users.
- **Educational research:** educational market, cooperation with teachers, curriculum developers and educator researchers. Although this is a continuing process, many of the requirements are over a very short period – often single days of concept workshop or of child observation are required.

The principal research questions are ultimately the identification of new products and how they are to be made. Making new products also involves longer term research, both technological research (eg plastics technology) as well as the application of educational and social sciences. The shorter term research includes market research.

Even a large multinational organisation needs to collaborate with academic researchers. Often, during recessions in business, the research budget is one of the first to be cut, but many organisations need to have reliable relationships with universities. Therefore being able to outsource research is important.

Case study:
the Science Museum

A major national museum has clear research needs. They have a number of research functions they carry out themselves involving a team that designs new experiences and a team that is involved in market research. The internal research teams use a variety of methods that respond to their own timescales - which are usually much shorter and require quicker initiation and response - than traditional university-based research. The research teams also need to develop metrics that are appropriate to a range of needs which include satisfying sponsors on the value of sponsorship, meeting Government targets and ensuring the effectiveness of exhibits on the museum's own terms. As far as possible the research team apply academic rigour to their activity and, in recent times, have published nine papers. They aim to become a leading venue for research into informal learning and to develop collaborative research projects with leading academic groups. Through this latest collaboration they seek to improve the practice of museum interpretation – exhibition development, design of interactive exhibits, and use of live interpreters – so as to increase the educational potential of the museum.

Research groups would gain the following benefits from a collaborative project:

- Access to the museum's visitors for research projects.
- Use of museum projects as research case studies for students and post-doctoral researchers.
- Access to the museum's audience research data.
- Mentoring and training for students and post-doctoral researchers.
- Contact with other leading practitioners in the museum and related sectors.

In return the museum would seek the following benefits from a collaborative research project:

- Access to research papers gathered during literature searches.
- Regular discussion groups: sharing of ideas; research articles; case studies.
- Contacts with other leading academic researchers and research groups.
- Consultancy on specific projects.
- Training and mentoring for museum staff.
- Joint long-term research projects linked to specific museum projects.

The museum sector has key research questions:

- Initiating and sustaining conversation among visitors and between staff and visitors is the key to increasing visitors' opportunities to learn. Specifically they want to learn more about: how to initiate and sustain conversation between visitors at objects and does technology have any part to play? How to initiate and sustain conversation between visitors and explainers? How to initiate and sustain conversation at interactive exhibits?
- Research in the design of interactive exhibits. Interactive exhibits can be a popular and effective educational medium for museums and science centres. Although much research has been conducted into visitors' learning from such exhibits there is still much to learn about how to design effective exhibits.
- What do visitors learn after the museum experience? Museums want to extend visitors' learning beyond the actual visit by providing opportunities for visitors to capture and review elements of their experience. They need to research the part technology has to play in this learning process.
- How can museums be more socially inclusive? People from ethnic minorities and lower socio-economic groups are under-represented in the audiences of museums and science centres. The museum needs to uncover the reasons why these segments of the population are under-represented and determine what strategies are effective in attracting and engaging these audiences. They are also interested in knowing what gender differences there are in engagement with the museum.

Case study:
a university experience

This case history is based upon a joint submission for funding to develop interactive mathematics learning resources. The partners were a university department with a strong research record in the field of ICT and mathematics and a neighbouring successful multimedia company. The case study expresses some of the concerns felt by researchers when engaging with industry, and it reflects the advice the researchers would like to give to industry. Accessibility of ideas, responsiveness and accepting the wisdom and needs of the partner are not just a one-way street. Commercial partners also have their own language and areas where they may seem inflexible.

The researchers were asked to help shape the proposal for new mathematics resources. The features that the researchers wanted taken into account were:

- Learning is a by-product of engagement – the message to designers was 'think about the objects and words with which you want the learners to engage'.
- Learners actively make sense as they engage – 'the design of the interface should be key to this, it must aid sense making'.
- Learners bring different perspectives to a situation and so make sense in different ways – 'there is a need to understand and anticipate these differences'.
- Good mathematics software provides rapid interaction and feedback – 'pay attention to how your environment can offer interaction and feedback'.

What actually emerged from the partner in response to this advice bore very little resemblance to what was expected. There was a lot of evidence to support the development of a narrative skin (eg mathematics transported to a world of aliens with lavish use of graphics), however the message imparted by these graphics was that there would be no intrinsic motivation to engage with well thought-out mathematics - rather it required a veneer of whimsy. Furthermore, the sample screens clearly indicated that the overlay of a comic graphic narrative would actually obscure the necessary clarity in concepts needed for the learner to 'make sense'. The company had produced a well-liked product that demonstrated their considerable visual design skills. However, from the researcher's perspective, a lot of educational thinking had become obscured.

It left the researchers with a need to think through the nature of partnership - the need for team work and the sharing of knowledge. The questions posed were:

- How can teams reconcile different perspectives? There is a clear need for longer term dialogue in order for understanding to be built.
- What is the role of knowledge? Neither side operates purely on hunches - both have bodies of knowledge that together can be evolved into new ways of doing things.
- What is the role of educational research? Educational research is not just about validating or adding credence to a company's offering – it should lead to change.

Case study:
BEAM Technology's Think Maths

Think Maths: Teaching and Learning Problem Solving is a multimedia CD-Rom for mathematics coordinators, teachers and LEA advisers to use for professional development.

It enables teachers to gain insight into the teaching of problem solving and provides 15 problems for teachers to solve with children across the primary age range.

To help teachers get started on problem solving the CD-Rom provides:

- Video sequences showing teachers using problem solving strategies with whole classes of pupils.
- An animated step by step for each problem which enables teachers to progress through a range of problem solving processes.
- A set of 15 problems for teachers and children to solve together. Many of the problems are set in an everyday context so they are of interest to children.
- Diagnostic assessment of samples of children's work.
- Teachers' notes.
- Children's resource sheets.
- A linked website giving further information on problem solving strategies and, if required, a set of slides which may be used for professional development.

Research on mathematical problem solving

There is extensive research into how teachers can best introduce mathematical problems to children. In this context problems are not simply addition or subtraction calculations put into an everyday context. This type of problem requires thinking skills: it may be open-ended, require a range of strategies and may even need little mathematical knowledge to reach a solution.

Problem solving in these circumstances is not a rote procedure - it provides the opportunity to explore, take risks and experiment and, in doing so, challenges both pupils and teachers. If successful it creates great satisfaction and enables that 'eureka' feeling once a problem is solved.

Mathematical problem solving is not an easy task. The issue in creating Think Maths was how to create challenges while helping teachers and children to enjoy the activities presented, gain confidence and achieve success. Research suggested that a book of problems on its own, even with solutions, would leave both children and teachers faltering. A CD-Rom with video, animation and printable text would provide the resources necessary to help teachers gain the confidence to get started.

Video

The video sequences show a whole lesson for each age range 5-7, 7-9 and 9-11. Research evidence suggests that teachers need:

- Encouragement to run a problem solving class (as problems are sometimes open-ended and solutions are not necessarily just right or wrong, many teachers see these activities as risky).
- To realise that problem solving is for everyone, regardless of ability.
- To see some problem solving strategies in action.
- To allow children to use their own strategies whenever possible.
- To develop the children's communication skills so that they can discuss their hypotheses together.
- To direct children's learning through asking the right questions at critical points without giving the game away.
- To draw in the whole class to reflect on different strategies and review solutions.

Case study:
BEAM Technology's Think Maths

Each classroom video was divided into three sequences: the teacher introducing the problem; children working in pairs or groups; and a plenary session to draw everyone's thoughts together. The first part showed teachers helping children in mixed ability classes to understand the problem, sometimes asking children what strategies they might use. The second sequence, in which children were working together, gave the opportunity to illustrate children's discussion and the questions teachers introduced to help them, especially if children 'got stuck'. The plenary showed teachers using solutions from the children to give an overall picture of the problem and its solution as well as the range of strategies used.

Animated step by step

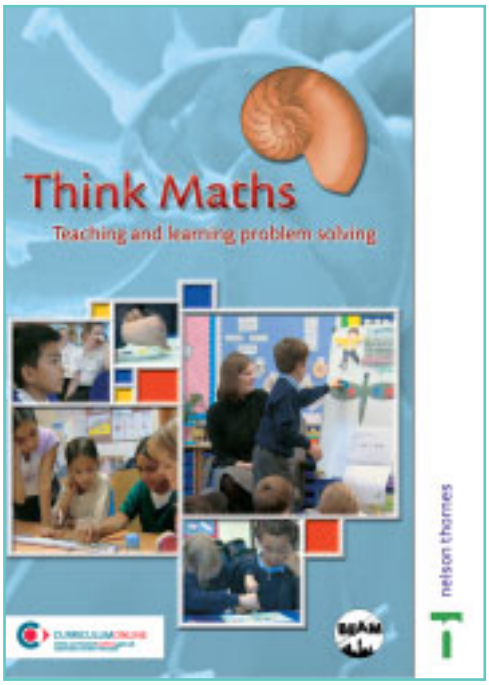
The 'animated step by step' takes teachers through the problem in a much more efficient way than can be done on paper. Sometimes problems are quite difficult to explain in text form so the animation enables teachers themselves to understand the problem quickly and see, at their own pace, how the solution unfolds. It also illustrates the dynamics of the problem.

Text resources

The text resources are more conventional in their approach. Illustrations of children's work with comments are provided to give help with assessment. Teachers' notes provide a back-up to the animations. They provide problem solutions as well as information on the mathematical skills necessary for each problem and ways of extending problems using similar strategies. The children's resource sheets state each problem clearly with an illustration and provide tables and charts to be completed if teachers feel that these will be helpful.

The web link

Research findings suggest that since problem solving often feels a risky venture for teachers, group meetings and the opportunity for discussion of classroom successes and failures is helpful. To this end the web link provides a set of slides that may be used in professional development sessions on problem solving plus more information on problem solving processes.



The CD-Rom provides a range of problems for primary school children. Each has been carefully thought through to be contextually appropriate to children of a particular age and to be within their mathematical capabilities. As George Polya, the guru on mathematical problem solving wrote: "A teacher should set pupils the right kind of problem; not too difficult and not too easy, natural and interesting, challenging their curiosity and proportionate to their knowledge."

Think Maths: Teaching and Learning Problem Solving is published by Nelson Thornes and BEAM Education and is available through Curriculum Online

What can the designer do now?

There is already a growing body of publications from Futurelab which is making research available to a wider audience. The Futurelab Literature Reviews are written by experts in their fields but in a style that makes the issues clear to a reader who does not regularly read educational research. They are in web and pdf format on the Futurelab website: www.futurelab.org.uk/research/lit_reviews.htm. These reviews cover a range of topics: some are subject-specific, eg on science or modern foreign languages; some are more generic, eg on learning out of school or the 14-19 age phase; and some are technologically-focused, eg on tangible interfaces.

There is a portal to all social science in the UK on the web: SOSIG. It is indexed and provides links to websites for research projects and to summaries of research that has been published in journals. Some of these journals are freely accessible on the web; for others, it is necessary to purchase the item or make contact with researchers who can access these journals easily through their institutional libraries. It can be found at www.sosig.ac.uk

Education-line is a freely accessible database of the full text of conference papers, working papers and electronic literature which supports educational research, policy and practice: www.leeds.ac.uk/educol/

There is an online database of the research funded by the ESRC on its Society Today database: www.esrcsocietytoday.ac.uk

Academic journals are indexed and searchable online. This is most easily done in university libraries that have staff who can help. Or you could approach a university department and commission them to do a review on a specific topic for you.

There are also journals that consist of abstracts of all the current journal articles on a particular theme. This makes browsing easier. In this particular subject area you might try Educational Technology Abstracts, which is published by Routledge.

Additionally, you can always contact Futurelab (www.futurelab.org.uk) or many of the participants in the seminar series.

Directory of educational researchers

Designers and developers working in the digital content and educational resources industry tell us that they find it difficult to identify expertise in educational research when they are producing a pitch for a contract, identifying market niches or developing a product. This was one of the issues that emerged from the seminars, and as one of the outputs we have produced a directory for access by industry practitioners or policy makers who want to benefit from input by educational researchers.

Users of the directory are invited to contact researchers directly to discuss their initial plans and requirements as well as the services that the researchers can offer. This might include any of the following (although this list of services is not exhaustive):

- Doing a review of existing research in a specific area.
- Providing information on children's learning and development at different ages.
- Providing advice on educational or leisure uses of specific technologies.
- Conducting usability testing.
- Contributing to feasibility discussions or brainstorming.
- Conducting an evaluation.
- Providing tailored knowledge on curriculum content or pedagogy.

The directory is organised by pre-school, primary and secondary sectors for ease of use. However, expertise is not limited to uses of technology in schools and researchers have indicated if they have a particular interest in informal learning and out of school contexts.

If you use the directory please note that it is your responsibility to negotiate a fee with the researcher and that Futurelab does not

What can the designer do now?

accept any responsibility for negotiations or the conduct of the work. We recommend that you negotiate a written agreement which details the fee, allowable expenses and the mechanism for payment before work commences.

Daily rates for academic researchers vary from £150 to £750+ depending on their eminence and rarity of expertise, the level of supervision they are providing, the types of outputs (eg written or oral reports) and the number of days contracted. Depending on the type of work and the institution contacted you may be able to negotiate a fixed fee for the work rather than a daily rate.

Research in the longer term

If you are interested in commissioning some research over a longer period of time it is worth considering sponsoring a CASE research studentship. This is a very cost effective way of involving academic research over a longer period of time (as described below) which will cover most of the costs of the studentship, with the industry or policy partner providing a fixed sum over three years. For this, they get access to PhD supervisors with expertise in the area as well as targeted research by the student for three years.

Collaborative (CASE) studentships

These CASE (Collaborative Awards in Science and Engineering) studentships are awards for research students to carry out projects in the social sciences in collaboration with companies/business. They provide PhD students with the opportunity to gain experience of work outside an academic environment. An academic supervisor and a company supervisor support the students.

The Economic and Social Research Council (ESRC) funds these awards. The standard industry or policy partner's minimum contribution is £4,000 per annum (£2,000 to the full-time student and £2,000 to the university department in which they are situated). The ESRC pays the student a stipend, currently about £12,000 per annum. The academic partner has to make an application to the ESRC but industry/policy partners may approach researchers to see if they are interested in a collaborative studentship. Please note that only some university departments are eligible to bid for these funds and the competition is held on an annual basis. There is currently a high degree of success (about 50%) in gaining funds for the studentships.

Further information may be found at www.esrc.ac.uk/esrccontent/postgradfunding/advanced_course_studentships_case.asp.

As an example of how these CASE awards work, Futurelab recently collaborated with three different university departments to fund PhD students:

- Play with me: Towards a framework for the design of preschool children's screen-based technologies – Prof Ros Sutherland at the University of Bristol.
- The design and evaluation of tangible technologies to support learning in early years and primary education – Prof Claire O'Malley and Prof Steve Benford at the University of Nottingham.
- Young Children and Digital Play – Dr Lydia Plowman and Dr Christine Stephen at the University of Stirling.

Knowledge Transfer Partnerships

Knowledge Transfer Partnerships work on similar principles but participating graduates do not necessarily register for a PhD. The arrangement can last for between one and three years and the scheme is funded by the DTI. Knowledge Transfer Partnerships enable universities to apply their wealth of knowledge and expertise to business problems and they are suitable for projects with more of a computer science or engineering component than those funded by the ESRC scheme. Each Knowledge Transfer Partnership is part-funded by a Government grant to the Knowledge Base Partner. This contributes to the costs it incurs through participating in that particular Knowledge Transfer Partnership, whilst the balance of the costs directly attributable to a KTP Associate's Project is borne by the company partner.

Further information may be found at: www.ktponline.org.uk/hei/