The Design of Learner-Centred, Technology-Enhanced Education

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A hypertext version of this thesis can be found at http://phd.richardmillwood.net

Abstract

This dissertation presents a thesis in the form of three analyses to support creative decision making in the design of learner-centred, technology-enhanced education. The thesis was developed through use and improvement in practice over three decades.

The dissertation also describes the action research methodological approach & methods employed and explores a framework based on concepts of design, learner, technology as a foundation for framing the thesis. Finally it evidences the claim for an original contribution to knowledge through an annotated selection from a portfolio of practice.

The experience gained through increasingly responsible work rôles, in which the author was expected to guide other designers, shaped the articulation of the three analyses which were made for evaluating designs as a springboard for iterative improvement. These analyses are:

- an 'expressive constructivist' model of learning;
- an account of how technology can support such learning;
- a learner-centred breakdown of questions to focus on progress in education more holistically.

This thesis arose from growing tacit and experiential understanding and has been informed by a theoretical and conceptual framework based on academic literature. It is argued that the successful application of these analyses in the practice cited has generated the validity of the thesis, and to a limited extent, reliability.

Figures

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Acknowledgements

In the Appendix 2 - People, I make extensive acknowledgement, to as many as I could recall, who touched my life throughout my practice and the development of my thinking, but special mention is given here to those who helped me to finish this thesis.

Firstly to my lead supervisor Stephen Powell, who has shown me the way by his example and has treated me with the perfect level of encouragement, admonition and advice at every stage - I consider him my extra brother. Dai Griffiths as supervisor has supported me enormously, especially in the final stages.

Thanks also to Margaret Nelson, Roberta Weber, Roger Carlsen, Brendan Tangney and Elizabeth Oldham who all offered me opportunity to talk about the thesis, listened and told me what for. I am grateful to examiners Sarah Younie and Clive Holtham for being so forgiving and thorough.

My mother, father, sister Liz and Joy Hooper have all enquired at regular and helpful intervals with love and respect and thus driven me on.

It is all their fault.

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1 Introduction

This section provides context to this thesis, including overall aims, information about the author and the nature & criteria for a PhD by Practice.

1.1 Aims

by Richard Millwood — last modified Sep 03, 2014 04:12 PM

The overall aim of my PhD research has been to make an original contribution to knowledge through my practice, founded on an emerging thesis in the form of three analyses to guide decision making in the design of learner-centred, technology-enhanced education.

The Claim section sets out the three key analyses which are referenced in the form [Ax] and these are supported with reference to the individual, specific and more diverse aims of my selection from a portfolio of practice, together with a triangulated assessment of my contribution to each item and their originality, impact and importance and the evidence for that judgement. These items of practice are referenced in the text in the form [Px] and can be found with a full description in Appendix 1.

1.2 Structure of this dissertation

The dissertation has the following sections

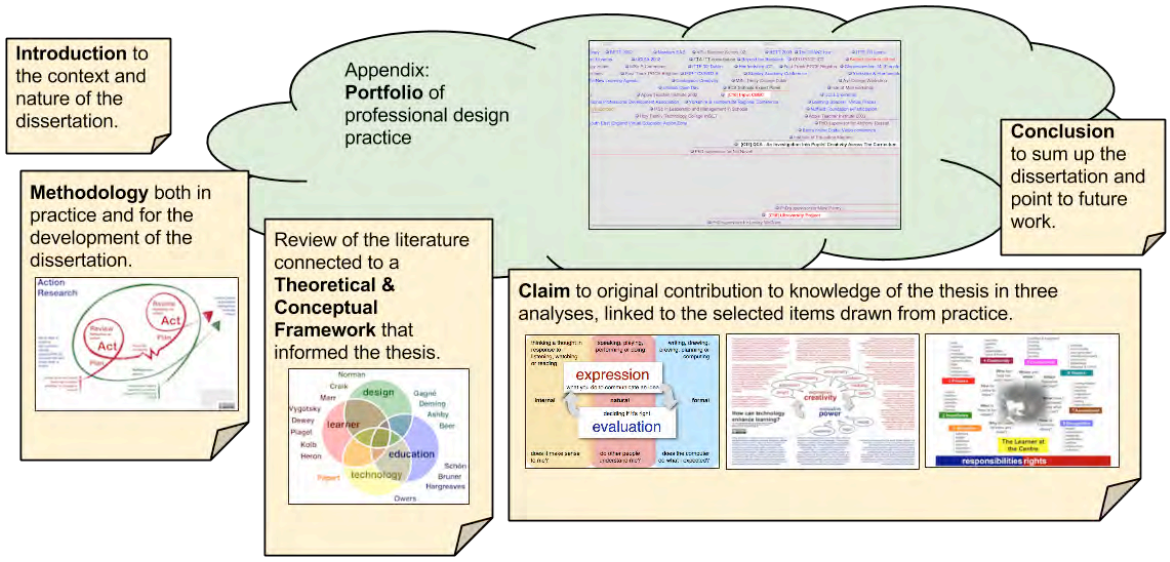


Figure 1: The structure of the dissertation

1.3 About Richard Millwood

In writing this dissertation, I came to realise that all the practice I had been engaged in had a common thread: an ambition to improve education through a better, theoretically-informed design practice for innovations using technology

I have been trying to do this since 1978 as a design practitioner in technology-enhanced learning. I have sought analytical and descriptive means to improve designs through effective design & development processes. I have focussed on learner-centred approaches and researched widely across multiple disciplines. My practice has also involved teaching at all levels, specifically at Masters level since 1984 and the supervision of PhD students since 1997.

I am currently a Director of Core Education UK Ltd, a non-profit organisation and I am Assistant Professor and Course Director for the MSc in Technology and Learning at Trinity College Dublin. Until July 2013 I was Reader in Distributed Learning in the Institute for Educational Cybernetics at the University of Bolton as well as a Research Fellow at Brunel University until September 2013. I am responsible for the National Archive of Educational Computing and contributor to the Work Focussed Learning project. I also maintain a blog, a New Learning Landscape, and occasionally tweet as @richardmillwood.

I am a Fellow of the Royal Society for the Encouragement of Arts, Manufactures and Commerce (FRSA) and of the British Computer Society (FBCS) and have been an Apple Distinguished Educator since 2000. I have recently served as a secondary school governor, having previously chaired a primary school governing body for six years. I am active in the Labour Party, currently serving as Chair of the Brentwood and Ongar Constituency Labour Party and I am a founding member of Educating Brentwood, a local group dedicated to improving educational accountability.

1.4 PhD by practice

The practice route to doctorate is designed for practitioners who have created major works and wish to present these for examination as original contributions in their field.

In my case, I am presenting my work as a designer of technology-enhanced, learner-centred education. In this dissertation, in the section titled 'Claim', I propose and offer evidence that some of this work has been state-of-the-art and has made substantial original contribution to the learning technology field.

I have straddled the groups of learning technologists and educational developers in my work, and these groups have only emerged in my lifetime, as reported in Alison Hudson's PhD Thesis 'New Professionals and New Technologies in New Higher Education?' (Hudson 2009).

Hudson's study suggests that:

> …both groups occupy a highly politicised position, are affected by the shifting value of social, cultural and economic capital in the constantly changing higher education, are subject to struggle regarding ‘position’ and agency and are susceptible to the demands of new power regimes and technological solutions.
>
> (Hudson 2009, Abstract)

My work has encompassed early years, school and informal lifelong learning, although throughout most of my career I have been employed in higher education research & development contexts, frequently in short term contracts and struggling to establish a 'position'.

This struggle with 'position' has made the PhD by practice suitable for my situation, since the combination of disciplines necessary to carry out my work has shifted from instructional design, to multimedia creativity, to course design and ultimately the design of systems of schooling and higher education. Thus I have never 'settled down' in any subject disciplinary sense, instead obtaining coherence from the focus on design, development, marketing, teaching and leadership in the creation of innovative 'products' at many levels. This combination of disciplines also leads me to draw broadly on theoretical and conceptual literature, and my literature review is spread throughout this thesis. Arguably I have experienced an ‘expansive education’, in response to Engstrom’s problem “the elusive and uncontrollable nature of expansive processes where human beings transcend the contexts given to them” (Engstrom 1987), in my case stimulated by new technology developments. Thus I have defined multiple aims in the process of developing this thesis since it is in the nature of expansive education that a single research question could not represent my original contribution.

The consequence of these matters, together with the shorter account (20,000 words), the absence of a standalone literature review chapter and the range of eclectic practice itself, makes this approach challenging as compared to those made in more traditional and focussed PhD forms. Winter et al, in their paper The 'Academic' Qualities of Practice: What are the criteria for a practice-based PhD?, address this question head on, and suggest (minimally) that:

> …a PhD ought to:
>
> - - be a report of work which others would want to read;
> - - tell a compelling story articulately whilst pre-empting inevitable critiques;
> - - carry the reader into complex realms, and inform and educate him/her;
> - - be sufficiently speculative or original to command respectful peer attention.
>
> (Winter et al 2000)

The regulations for the Bolton PhD by Retrospective Practice demand that the thesis should consist of:

> A rigorous critical appraisal, normally between 10,000 and 15,000 words
>
> (University of Bolton, 2008)

The regulations give 5 specific criteria, set out here in table 1 to guide the reader within this thesis to locate my response.

Table 1: Specific criteria for the PhD by Retrospective Practice at the University of Bolton and my response

Criterion	Response
1. details of specific dates and locations in relation to the conduct of the research on which the submission is based;	To be found in the first Appendix - Portfolio
2. an analysis of the general and specific aims of the research programme, including an analysis of its component parts and a synthesis of the works as a coherent study;	To be found in the overall aim stated in the Introduction and in the aims for each item of practice in the Claim section.
3. a discussion of the contribution made by the submitted works or evidenced by the items within the portfolio to the general advancement of the field of study and research area or professional or creative practice, which demonstrates a common theme;	To be found in the summary of the Claim and the discussion of each item of practice in the Claim, where reflections on learning, contribution, originality, impact and importance are made and empirical support for the the three analyses which form the thesis. The Conclusion includes a summary of the contribution.
4. a demonstration that the work or the practice constitutes an independent and original contribution to knowledge in the chosen field;	To be found in the discussion of each selected item of practice in the Claim, where reflections on learning, contribution, originality, impact and importance are made.
5. a review of the current literature, unless already incorporated within any of the other items submitted.	To be found throughout in the Methodology, Theoretical & Conceptual Framework and Claim.

2 Methodology

There are three aspects to this section - firstly an overview of my research approaches, secondly a discussion of the research methodologies I have developed in my practice, and thirdly a discussion of the methodology employed in developing this dissertation.

2.1 Research approaches

This section describes the overall approach for both my practice throughout my career and the production of this dissertation. Both were founded in iterative cycles of development based on an action research paradigm. It also explains the values that have been at the heart of my practice and the ethical issues that have arisen.

2.1.1 Research approach developed in practice

The design of software, resources and systems I have developed has been undertaken in the context of a series of research projects. The inquiry paradigm of these projects started with creative curriculum development in the early part of my career and later became overlaid with a more explicitly collaborative action research approach (Lewin 1973, 205-6; Argyris and Schön 1978), within and on the education system itself. My mature visualisation of this approach is shown in the following figure, developed as a wall poster:

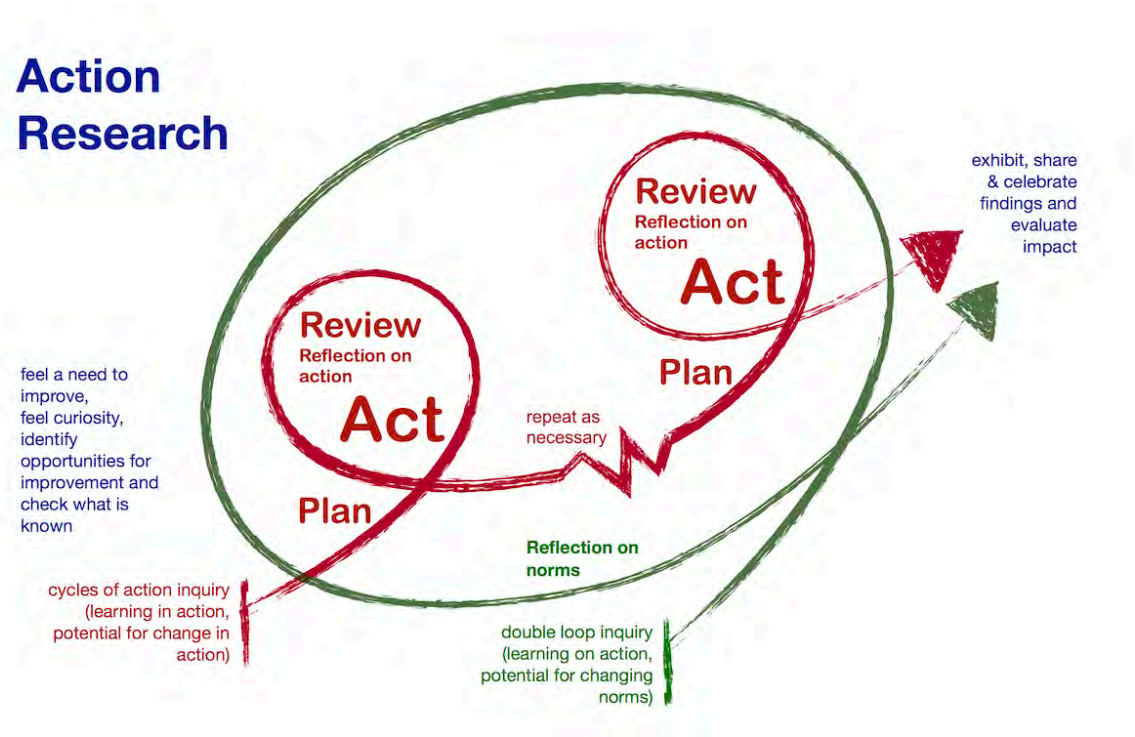


Figure 2: A model of action research

This paradigm is not without its problems, as Somekh and Zeichner put it:

> Action research, as a proposition, has discursive power because it embodies a collision of terms. In generating research knowledge and improving social action at the same time, action research challenges the normative values of two distinct ways of being – that of the scholar and the activist.
>
> (Somekh & Zeichner 2009, p5)

This notion of two ways of being has specific attraction for the designer & developer in me, who loves to make and do, not simply think and reflect. Thus it has been natural for me to engage in the iterative and cyclical phases of action research - planning, acting, reviewing and with growing awareness of its meaning. Planning has included collaboration with experts, practitioners and learners inspired to envision the potential for innovation with technology in education. Acting has ranged from coding programs, creating CD-ROMs, designing web-sites, configuring online communities, teaching, facilitation, marketing of courses and direction of large teams of colleagues. Reviewing has involved empirical data collection methods including observation, interview, focus group, survey and videography. This has been followed by analysis of the quantitative & qualitative data collected and subsequent interpretation to develop conclusions which inform the next cycle of inquiry. Double loop learning, the identification and critical questioning of governing variables (Argyris and Schön 1978), has been common throughout as I and collaborators bloodied ourselves confronting the inherent conservatism of educational practices, institutions and frameworks whilst making sense of technology innovations.

This action research approach and all these methods have been employed in my practice as part of the many research and development projects undertaken, and they are described and exemplified in the section Methodologies developed in Practice.

2.1.2 Research approach to the dissertation

When setting out to develop this dissertation, I decided on a reflective methodological approach (Dewey 1933, Schön 1983) and related methods to construct it, but, keeping true to my practice of design and what drives me, the design and development of a resource in the shape of a web site was a vital element. The steps taken to arrive at the substance and presentation of my dissertation are discussed in the section Methodology for this dissertation.

This web-site can be found at http://phd.richardmillwood.net/

2.1.3 Values driving the research

The research and development I have been engaged in has always been values-driven, in a nutshell 'to change the world for the better'. Over time these values have developed, but they clearly indicate a subjective viewpoint, and thus run the risk of introducing bias and overlooking issues.

Friedman et al explain that the motivation for such values cannot be purely empirical:

> "values cannot be motivated only by an empirical account of the external world, but depend substantively on the interests and desires of human beings within a cultural milieu"
>
> (Friedman et al 2006, 2)

Friedman et al explain the background to a values-based approach (Friedman et al 2006, 2) and then go on to exemplify these, see table 2: *Human Values (with Ethical Import) Often Implicated in System Design* (Friedman et al 2006, 17). These tend towards individual rights of users rather than responsibilities, in a context of designers and users. The authors also note that the set is not comprehensive.

Table 2: Human Values (with Ethical Import) Often Implicated in System Design

Human Value	**Definition**
Human Welfare	Refers to people's physical, material, and psychological well-being
Ownership and Property	Refers to a right to possess an object (or information), use it, manage it, derive income from it, and bequeath it
Privacy	Refers to a claim, an entitlement, or a right of an individual to determine what information about himself or herself can be communicated to others
Freedom From Bias	Refers to systematic unfairness perpetrated on individuals or groups, including pre-existing social bias, technical bias, and emergent social bias
Universal Usability	Refers to making all people successful users of information technology
Trust	Refers to expectations that exist between people who can experience good will, extend good will toward others, feel vulnerable, and experience betrayal
Autonomy	Refers to people's ability to decide, plan, and act in ways that they believe will help them to achieve their goals

Informed Consent	Refers to garnering people's agreement, encompassing criteria of disclosure and comprehension (for 'informed') and voluntariness, competence, and agreement (for 'consent')
Accountability	Refers to the properties that ensures that the actions of a person, people, or institution may be traced uniquely to the person, people, or institution
Courtesy	Refers to treating people with politeness and consideration
Identity	Refers to people's understanding of who they are over time, embracing both continuity and discontinuity over time
Calmness	Refers to a peaceful and composed psychological state
Environmental Sustainability	Refers to sustaining ecosystems such that they meet the needs of the present without compromising future generations

The values I identified diverge and are a subset of theirs, and focus on responsibilities on both designers and users as partners in design.

The approach I have taken here has been to identify the key values that have driven my work, critically recognise the risks whilst maintaining a moral & ethical perspective and where possible, make a connection with Friedman et al's set.

2.1.3.1 Collaboration

This value is related to Friedman et al's 'Trust' and 'Autonomy'. All the research and development I have engaged in recognises that collaboration is essential. The positive features for me are:

- a continuing dialogue of critical friendship;
- the benefit of diverse strengths and perspectives;
- where possible, the democratic involvement of beneficiaries and stakeholders to improve ideas, evaluation and uptake.

This follows the approach of Cooperative Inquiry (Heron and Reason 2006, 144-152) which recognises an approach where people with similar concerns work together to make sense of their world, developing creative ways of considering problems and learning how to bring about change in things that they want to improve.

Heron and Reason (ibid.) identify two participatory principles:

> epistemic participation, “propositional knowledge that is the outcome of the research is grounded by the researchers in their own experiential knowledge”; and
>
> political participation, “research subjects have the basic human right to participate fully in designing the research that intends to gather knowledge about them.”

This approach rejects the division of practitioner and researcher into different roles. Instead, it sees inquiry as a social process that is emancipatory, in that allows those who participate to be considered both as researchers and as themselves.

Boylorn (2008) identifies:

> Participants as co-researchers refers to a participatory method of research that situates participants as joint contributors and investigators to the findings of a research project. This qualitative research approach validates and privileges the experiences of participants, making them experts and therefore co-researchers and collaborators in the process of gathering and interpreting data.
>
> (Boylorn 2008)

One risk has been an 'averaging' of creative ideas to achieve consensus, but on reflecting back over my practice, this has rarely prevented innovation. Another relates to the relative lack of expertise, which may limit the participant's ability to contribute. This is particularly so when working with students, but the benefits can be unexpected. With higher expectations, young people often step up to meet them, as discovered in the context of the [P6] Étui project, where we invited children to act as researchers to evaluate toys and their design.

2.1.3.2 Critical friendship in research

This is related to Friedman et al's Freedom from bias'. It has been vital throughout my practice to invite colleagues to comment on plans, activity and analysis.

Costa and Kallick (1993) define a critical friend as:

> a trusted person who asks provocative questions, provides data to be examined through another lens, and offers critiques of a person’s work as a friend. A critical friend takes the time to fully understand the context of the work presented and the outcomes that the person or group is working toward. The friend is an advocate for the success of that work.
>
> (Costa and Kallick 1993)

I have valued many critical friends, listed in the Portfolio and acting as a critical friend to many colleagues, and so this has been an important value in my practice.

The risks include the potential for breakdown of relationship and trust, as Cost and Kallick (1993) put it:

> Because the concept of critique often carries negative baggage, a critical friendship requires trust and a formal process. Many people equate critique with judgment, and when someone offers criticism, they brace themselves for negative comments.
>
> (Costa and Kallick 1993)

2.1.3.3 Social justice

This is related to Friedman et al's 'Freedom from bias'. The idea that research and development might address inequalities of opportunity in society through education has been central to my practice. I have tried to follow Light and Luckin's (2008) proposal that we :

> address the way in which TEL and user-centred design approaches can offer learners an experience that meets their individual needs and addresses the needs of minority groups as well as the majority
>
> (Light and Luckin 2008, 30)

Thus I have avoided methodologies such as experimental design, which favour one group over another through a treatment group and a control group and to favour more participative and naturalistic approaches using qualitative methods to evaluate outcomes. In the design process it has meant paying attention to diversity, culture and gender issues and making positive efforts in the design of innovations to address these. This has occasionally needed to counter technology-led innovation, which so often simply addresses 'normal' users.

The risk is that in some cases, a compromise has been needed between exploring new designs and addressing accessibility, whilst maintaining a moral and ethical view of the issue.

2.1.3.4 Transparency and participation

This could be the opposite of Friedman et al's 'Privacy'. My first software development work as a full-time researcher at Computers in the Curriculum in 1980 obliged me to work closely and to be led in pedagogical issues by teacher-groups and individual teachers leading on items of software. This demanded a transparency in planning and participation in design which I came to value. The returns were a growing awareness of practising teachers' knowledge and concerns combined with a practical means to deliver on the values of social justice. This in turn led to design and development criteria informed by my practice working with the teachers. In later projects, especially at Ultralab in the 90s this approach was extended to include school students as 'co-researchers', inviting them to understand the goals of our developments and to contribute at every level.

The risks relate to privacy and safety for participants, which can be undermined with too much transparency.

2.1.3.5 Delight

There is no equivalent to delight in Friedman et al's analysis. The intuitive idea that delight was essential to successful learning was a central tenet in Ultralab in the 90s, encouraging the team to develop software for learning with features intended to inspire delight in learners. Hargreaves analysis of teacher types as 'lion-tamer', 'entertainer' and 'new romantic' (Hargreaves 1992, 163) had prepared me for considering the affective nature of learning, but it wasn't until 2006 that I realised how much tacit knowledge had been developed by myself and colleagues to support delight as a value in design. The demands of articulating this fully in developing and presenting a television programme on well-being in schools for the Teachers' TV's School Matters series (Millwood 2007), helped me to recognise the nuanced detail of the concept and how deeply it had become key to my design and development practice. John Heron (Heron 1992, 122) theorises that delight may be experienced in multiple ways: 'appreciation' arising from a love of aesthetic form, 'interest' from a love of knowledge and 'zest' from a love of action. These delights are individual in nature, so I extended this analysis (Millwood 2008a) to propose three delights that are derived in association with other people: 'conviviality' from a love of company, 'recognition' from the love of achievement and 'controversy' from a love of dissent. All six of these delights have become important guides to effectiveness in my practice of designing educational experiences.

The risks in this value relate mostly to the diminution of delight and its confusion with 'fun', so often considered to be in opposition to the hard work that learning demands and thus a distraction.

2.1.4 Ethical issues

With the breadth of research & development undertaken throughout my practice, there have been a full range of ethical issues confronted. Particularly relevant have been issues of privacy and data protection with regard to minors, particularly as we developed large scale action research with school-aged children and in online environments. Measures to ensure appropriate ethical practice in the projects undertaken have been dealt with through the arrangements in place with my employers, the participants and their host organisations where relevant, but in some cases these had to be developed further in the context of new risks posed by the use of online technology and visual media.

In developing this dissertation, the main ethical concern has been to obtain the informed consent of colleagues I have described in the Portfolio. This has been done through invitation to review the materials and respond - all those who are still living have been kind enough to provide that. It has been essential to write about others, even though this dissertation is about my thesis and my practice, since:

> writing the Self without acknowledging the Other is itself a violent (symbolic) act against the ethical condition that comes with being human.
>
> (Roth 2009)

Thus, since so much of the practice I have engaged in has involved collaboration, it would be ethically unreasonable not to explain others' contribution to the thesis outlined in this dissertation.

2.2 Methodology developed in practice

Over the span of my practice I have adopted a range of methodologies and employed many methods, as well as supervising students for Bachelors, Masters and Doctoral dissertations as they developed their methodological approaches and applied methods. This section focusses on those methodologies that I have developed and applied directly in my design practice.

2.2.1 Research approaches in practice

2.2.1.1 Design & development

The key approach in my practice has been the design and development of educational software, multimedia resources, systems and ultimately courses. This design approach has been in a context where new technology offers new and unknown opportunities and despite disquiet about technology-led approaches, has inspired creativity and innovation in my practice. The key to this research approach has been a combination of developing design methodology and rigorous evaluation in real-world contexts. In this sense, I have been unconsciously engaged in a 'design science' approach as discussed in the Theoretical and Conceptual Framework section of this dissertation.

2.2.1.2 Participant action research

As my work developed, I became increasingly conscious that I was developing a participant action research approach (Denzin and Lincoln 2005, 33-34) to complement design & development. This was the result of a growing interest and opportunity to design courses, degree programmes and ultimately secondary (Notschool.net project) and higher education organisation ([P9] Ultraversity project). In each case the concept of co-research with students became ever more explicit.

2.2.2 Specific Methods Used

2.2.2.1 Prototyping, iterative development and field testing

In developing new interactive educational software, an early discovery was that the traditional waterfall method (Bell and Thayer 1976), of identification of user needs followed by specification, implementation and testing, would not work. Participants (including myself) in the design process were discovering new needs, had little ability to specify unknown designs offering new practices and found themselves learning through the process of development in an 'expansive' sense (Engstrom 1999). A further complication in practice was that the computers in use had a range of features and capabilities and the design team would often have diverse understandings of what could be achieved. So the method employed was of prototyping initial ideas to produce a working design, not fully debugged nor complete, to inform the next steps and inspire further invention.

Prototyping was only the beginning of course, and was followed by cycles of development and field testing, often in classrooms by the teacher participants in the design and development process,

whose understanding was also growing. Alongside the successive improvement in the software itself, there was a parallel and important task to develop the teachers' and students' guidance material which underwent a similar process.

As Mor puts it:

> The design element in a design study may refer to the pedagogy, the activity, or the tools used. In some cases, the researchers will focus on iterative refinement of the educational design while keeping the tools fixed, whereas in others they may highlight the tools, applying a free-flowing approach to the activities. In yet others they will aspire to achieve a coherent and comprehensive design of the activity system as a whole.
>
> (Mor 2010, 27)

2.2.2.2 Analysis of software designs

Frequently in the design process, a failure in use would be identified in broad terms - a teacher or student would report that some aspect was unclear, difficult to use or simply baffling. At this point it was important to analyse the software design (and the practice) to discover where improvement needed to be made. At first this was done informally and with tacit knowledge of 'what works', but this task was improved to make use of insights from the worlds of visual design and from human computer interface. The input from visual design and cognition theory (Marr 1982, Scrivener 1984, Gregory 1966) offered clarity about the simplest ideas of placement and the overlapping of graphical elements on the screen, the treatment of 'white space', typography and combinations of colours. The input from human computer interface theory was primarily from Donald Norman's Four Stages of User Activity (Norman 1983b), regarding the task analysis of operating equipment. We designed our own interpretation of this model to guide colleagues in our team - An Analysis of a Single Interaction (Millwood and Riley 1988), but oriented to operating a piece of educational software.

2.2.2.3 Online and interactive questionnaire surveys

In later practice, relating to the development of courses and self-evaluation, surveys that directly questioned participants became an additional method used (Lodico et al 2010, 12). The advent of low-cost online surveys, which also gave the researcher (academic or participant) an immediate and easily repeated summary analysis, meant this became an important method. I engaged in methodological development, writing new software to take advantage of the particular strengths of interactive designs. The strengths are that instead of using coding systems, letters or numerical values to rank or select choices, this can be achieved through interactive objects and sliders, building on kinaesthetic and visual thinking of respondents to help them more directly make the judgements about an issue being surveyed.The first venture in this direction came in the design of Making Choices (Millwood 1993), a tool for modelling decisions by interactively dragging choices into rank order and the COGs passport (Millwood 2004), a tool for transition between primary and secondary schooling. COGS helped learners evaluate their competencies by dragging elements in

a geometric design. This survey method was developed most recently in the design of interactive learning needs analysis for health professionals and volunteers in the charity Macmillan Cancer Support.

2.2.2.4 Videography

In several projects, understanding the holistic context and seeing the detailed activity became important. In these cases, making video of the activity or of the discussion to evaluate it was employed, although this could prove challenging to access and analyse (Jewitt 2012). Shrum et al describe the 'fluid wall' and the 'videoactive context' to emphasize that (a) the camera is an actor, and (b) both behaviour and observation occur in both directions -- in front of and behind the camera (Shrum et al 2005). These notions have been frequently employed for projects in which I have been active to explore digital creativity with children.

In some cases, the video was transcribed and the transcription added to the video as a 'text track' which was searchable. Added value could be obtained by adding text tracks for chapters and for keyword analysis, permitting the video to be used as the vehicle for exploration and dissemination of research findings, not simply the data gathered. ([P9] Ultraversity Project)

Although lowering of costs of equipment, media and the labour necessary to process have made this an attractive option, there are drawbacks associated with the quantity of data generated and the difficulties of processing, but these are offset in many cases by the direct and rich way in which knowledge of the research context can be communicated.

2.2.2.5 Structured Interview

In creating innovation in higher education, it became important to evaluate the experience of students and tutors in greater depth. In these cases we developed interview frameworks, conducted the interviews, recorded the audio transcribed and then employed an interpretive phenomenological analysis (Smith et al. 2009) to the data to discover in a grounded sense, the key themes of their response to our innovations (Millwood and Powell, 2009). These methods were particularly helpful in identifying conceptual knowledge in novel contexts offered by technology, although limited in reliability due to modest sample sizes and the potential for researcher bias (Brocki & Wearden 2006 101).

2.3 Methodology for this dissertation

This section explains and critiques the methodology used in the completion of this dissertation as opposed to the methodology applied in my practice. It begins with the philosophical and methodological approaches taken and the specific methods used to create the dissertation and discover my thesis.

2.3.1 Philosophical Approach – Pragmatism

The philosophical approach of Pragmatism - that the function of thought is as an instrument or tool for prediction, action, and problem solving (Peirce 1935; James 1898) - has inspired my work and

guided the production of the thesis. The analyses are essentially thoughts expressed in a form that enables them to guide action in the design process. An influentual development from Pragmatism that informed my approach is that of Symbolic Interactionism (Mead 1934) - that people act on things based on the meaning those things have for them; and these meanings are arrived at through social interaction and modified through interpretation. Mead proposed that the true test of any theory was that "It was useful in solving complex social problems" (Griffin 2006, 59) and this has guided me to develop and defend the analyses in my thesis by gathering my work practice, discovering those aspects which have made the greatest contribution and attempting to link them to the thesis through the development of a hypertextual dissertation web site, before creating the paper document.

2.3.2 Methodological Approach – Autoethnography

Although it is clear that the approach I have taken is of autoethnography, there are variants, and my approach has been closest to that defined by Ellis - “research, writing, story, and method that connect the autobiographical and personal to the cultural, social, and political” (Ellis 2004 pxix). Although I set out to describe and look critically at my experience, there is also the deliberate attempt to find theory in this dissertation, and a move from my tacit theories to those articulated in the analyses, [A1], [A2] and [A3], published with this dissertation, where the intent is to provide reliable tools to other designers. I hope that this desire and the positive outcomes of much of the practice I have been engaged in will counter the criticisms levelled at auto-ethnographers as "unscientific, or only exploratory, or subjective" (Denzin and Lincoln 2005, 8).

2.3.3 Bias

Autoethnographic approaches are criticised:

> for being biased, navel-gazing, self-absorbed, or emotionally incontinent, and for hijacking traditional ethnographic purposes and scholarly contributions
>
> (Maréchal 2010, 45)

I would counter this concern with the observation that this dissertation is not concerned with simply depicting my practice, but with setting out an abstract and theoretical thesis which is justified by the account of practice. In this sense, the autoethnographic approach recognises the capacity for bias, but is concerned to be faithful and productive to the author's thinking and experience. Triangulation of this account comes from the evidence cited in the Claim section.

2.3.4 Evaluating autoethnographic work

The five factors described by Richardson (2000, 15-16) for evaluating such work are used here to justify my position, and for you the reader to judge my success as set out in table 3.

Table 3: Richardson's factors for evaluating autoethonographic work (Richardson 2000, 15-16)

Factor	Response for this dissertation
Substantive contribution Does the piece contribute to our understanding of social life?	Taken as a whole, the portfolio explains the career of an individual (me) in times of change in education as technology matured and became ubiquitous, changing the face of education. I have related my development to the more influential people that I worked with, but recognise a huge number of others that made my work and learning possible.
Aesthetic merit Does this piece succeed aesthetically? Is the text artistically shaped, satisfyingly complex, and not boring?	This dissertation is also presented as a designed web-site, attempting to please aesthetically.
Reflexivity How did the author come to write this text? How has the author's subjectivity been both a producer and a product of this text?	In reviewing all my professional practice to prepare for this dissertation, I have systematically developed reflective written material for the most significant events. I have constructed identity and place in my life's work through this process and this has made me a product of this text.
Impactfulness Does this affect me emotionally and/or intellectually? Does it generate new questions or move me to action?	The demand to articulate more clearly my theoretical perspectives and find coherence in them has provided many questions. Impact has also been seen in the outcomes of my practice.
Expresses a reality Does this text embody a fleshed out sense of lived experience?	By including my employment, education and professional responsibilities I have tried to show a complete career. Although I could have included much more personal matters of family and relationship, the reflective section in my portfolio about people I have worked with will, I hope, illuminate how I have been humanly influenced.

2.4 Specific method used to develop the dissertation

2.4.1 Designing the dissertation web site

From the outset, the processes of gathering, categorising, reflecting, selecting and presenting were identified as knowledge and information management tasks, which from the author's perspective demanded the use of a content management system (CMS). The practice of designing using such a system was aligned with the author's experience and ambition, offering not only a vehicle for development but also dissemination and participation. The benefits of structuring, semantic tagging, work-flow, language translation, accessibility, visual design and multimedia features of the Plone CMS were seen as appropriate for the task based on experience using this CMS for the websites of key relevant professional organisations in recent years - Ultralab, Core Education UK and the National Archive of Educational Computing. These methods match digitally the way in which many dissertation writers will adopt a paper filing system using boxes, but permits greater flexibility of organisation and the potential for searching and sorting the data generated as the process unfolded. It ultimately offered me, as a designer of digital artefacts, the opportunity to use my online design knowledge and capacity to solve a challenging data handling problem as described in the following sections.

2.4.2 Gathering the evidence of practice

The first step was to enter the events in my practice using the 'Event' content type in Plone and collecting these in the Portfolio section. Each event consisted of a title, summary, description, start and end date for each of the elements of my practice. I chose to be broad in scope, creating an auto-biographical account which is more complete than required for this dissertation, but allowed decisions on relevance, importance and contribution to made through a second pass. An important consequence of this process was the positive effect of building a rounded account of my life experience leading to a holistic picture. The outcome is a list of around 400 items of practice.

2.4.3 Categorising the evidence

Each entry was tagged as belonging to one of seven categories that emerged from considering the kinds of practice I had engaged in:

- education - events in my formal lifelong education;
- employment - posts held;
- project - research and development projects undertaken;
- professional - positions of professional activity, e.g. societies, examination, advice;
- conference - participation in conferences;
- publication - papers and other media published formally;
- teaching - activity where my rôle was to teach others.

2.4.4 Adding reflections on practice and selecting key contributions to knowledge

To create a manageable portfolio for assessment of this dissertation, a selection of events was made that seemed to offer potential for the development of a doctoral thesis through a process of reflection (Dewey 1933, Schön 1983), following the requirements for this kind of PhD. These events were edited to include a paragraph or more of reflective writing, identifying the key elements within them that influenced the development of my design practice and assessing the contribution made by me in what were frequently collaborative activities. As well as clarifying the nature of my contribution, I assessed the proportion of it by recalling the size of the team I worked with, the role I was playing and the quality of my involvement. This was reduced to a single percentage value (as the regulation expected) and then verified by consultation with the key team member.

From these items, a further selection was made to shorten the list to form the basis of a claim for examination. These items are tagged 'claim' and show with a white background and bold text in the portfolio timeline as shown in Figure 3.

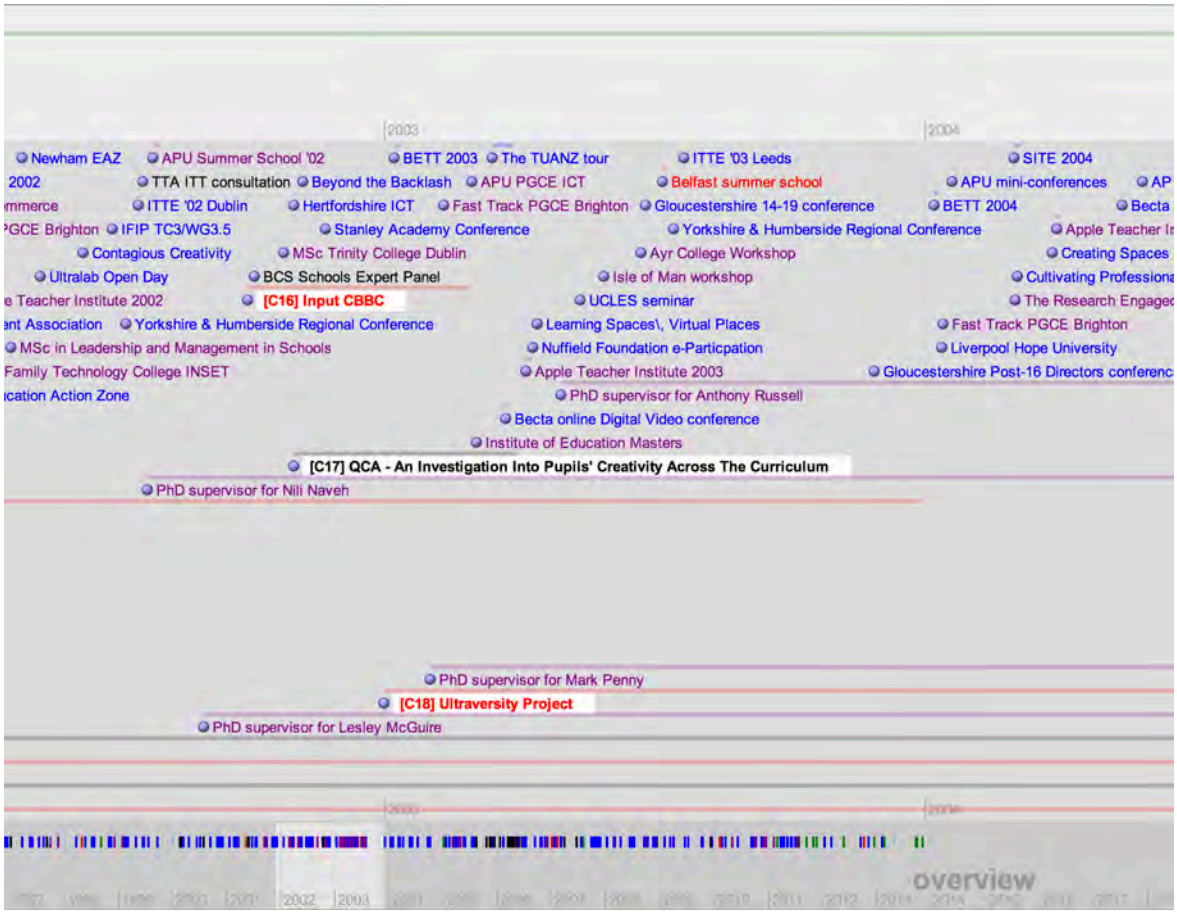


Figure 3: Claim items highlighted in white on a timeline of my professional practice

Each of these items has been shared with the original key collaborators, where possible, and they have formally agreed to my judgment of contribution. The collaborators were sent an email invitation to confirm my judgement with a letter attached to sign and return to my director of

studies.This process was followed as part of the conditions for registration for this degree and was submitted to the Board of Studies for Research Degrees and approved.

There are two areas for doubt in this case: firstly that the collaborators may have been influenced by personal relationship and thus unwilling to challenge the percentages proposed; secondly that the quantitative measure does not adequately portray the contribution made. Nevertheless this was the required method to indicate and confirm contribution as set out in the regulations:

> " iv. Where any work has been published or carried out in collaboration with other persons, a statement signed by the candidate and co-authors or collaborators specifying the extent of the relative contributions of each to the work. (Note: the University reserves the right to consult with any of the co-authors or collaborators in respect of this statement)."

(Regulations and Procedures Governing the Award of the Degrees of: Doctor of Philosophy by Published Work and Doctor of Philosophy by Practice Approved by the Board of Studies for Research Degrees Approved by the Academic Board, October 2008 Version 3 p5)

I was conscious of the limitations of such an approach in terms of my bias, and so deliberately determined a percentage contribution as low as seemed reasonable to me, for example usually not exceeding an equal contribution based on the number of members in the team and sometimes lower.

On reflection, I consider the requirement to estimate my contribution in percentage terms to be too limited, and in future would propose the regulations change to use more qualitative terms ranked as:

- leader;
- one of a pair;
- member of small team;
- critical friend and
- member of large team.

2.4.5 Identifying originality, impact and importance in practice

A final process of identifying the originality, impact and importance of the items of practice on which I based the claim was undertaken and referenced to evidence to corroborate my judgement. In some cases the practice was very public and on the large (national and international) scale and may be readily judged for these factors by other academics and practitioners in the field.

The outcome of this process forms the basis of the Claim made in that section of this dissertation.

3 Theoretical & Conceptual Framework

This chapter critically reviews the main theoretical issues which have been influential in the practice and the central concepts which developed.

3.1 Overview

The four concepts of design, learner, technology and education intersect to provide an overarching conceptual framework for the practice, which occurred in the intersection of all four.

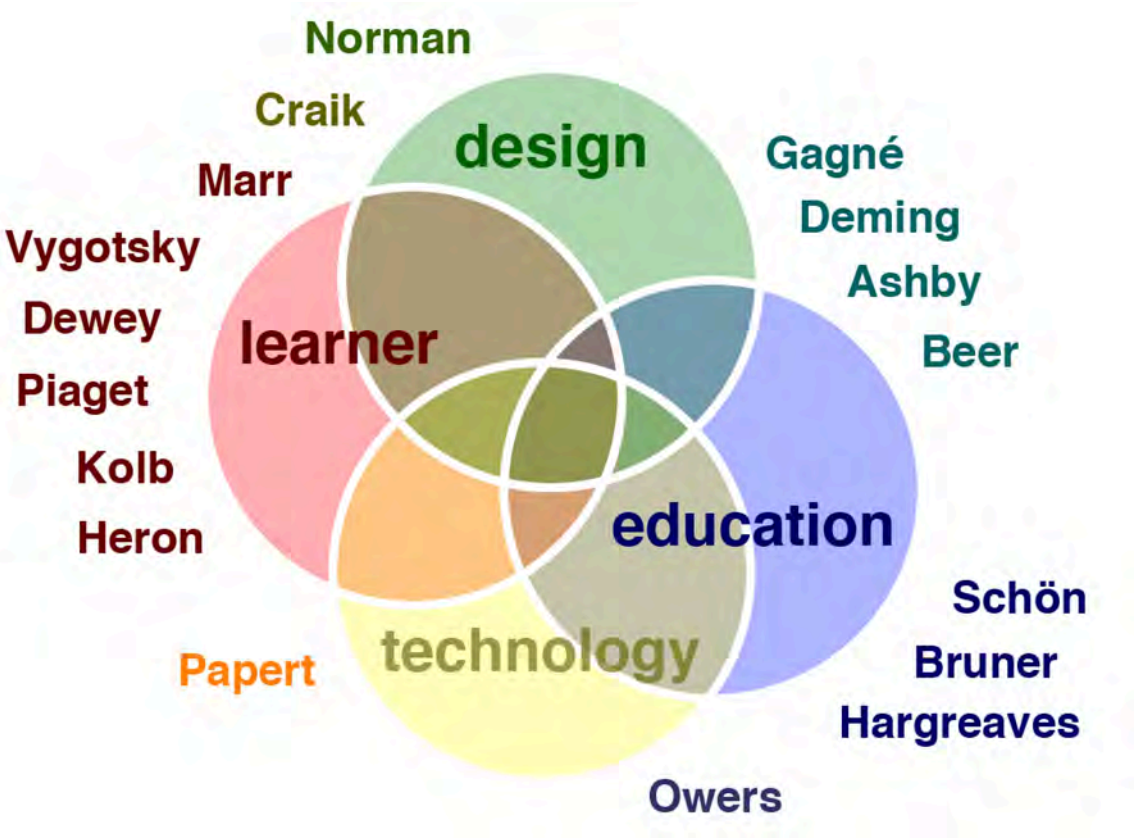


Figure 4: Conceptual framework for this thesis

The authors that surround the four concepts, shown in Figure 4, are the most significant theorists of those that have provided the author with insight, foundation and explanation for the design challenges experienced. Increasingly responsible rôles as a teacher, software developer, media designer, team leader and director, together with a natural proclivity to be reflective practitioner, broadened and deepened the author's understanding of the criteria for improving design quality in iterative design cycles, informed by these authors' theories.

I recognise the following description of the reflective practitioner in myself:

> The practitioner allows himself to experience surprise, puzzlement, or confusion in a situation which he finds uncertain or unique. He reflects on the phenomenon before him, and on the prior understandings which have been implicit in his behaviour. He carries out an experiment which serves to generate both a new understanding of the phenomenon and a change in the situation.
>
> (Schön 1983, 68)

Much of my understanding began as tacit in nature, but the need to lead design, prepare design guidance and collaborate with both technical and pedagogical colleagues demanded explanation. Extensive opportunities to present at conferences and workshops, improved the explanations and created the need for a simplified and coherent framework, represented by three key analyses, which comprise the thesis set out in the Claim section:

- [A1] Expressive constructivism - a creative and constructivist view of learning itself, founded on the concept of learner;
- [A2] How can technology enhance learning? - some of the key contributions technology can make to learning, founded on concepts of technology and learner;
- [A3] The learner at the centre - a learner-centred, holistic view of the decision points in education, founded on concepts of learner and education.

The issues of design science, mental models, learning theories, teacher types and the symbiosis of technological and human evolution are the major themes discussed in the following sections.

3.2 Design

The concept of design employed in the author's practice extended from the imaginative formation of learning resources, environments and systems to their development and evaluation and culminated in the innovation of courses and organisations for education.

3.2.1 Definitions

Design as a verb entails the process of imaginative formation of an entity. In the context of education and this dissertation, the entity, which may be as simple as a text or as complex as an organisation, may be a response to some or all of the key questions to progress learning, from motivation to recognition as set out in my analysis The Learner at the Centre [A3].

Design as a noun is concerned with the specification of such an entity. A more formal, nuanced and rich discussion can be found in Ralph and Wand (2009 , 118), where they define Weltanschauung (worldviews) of design thus:

Table 4: Worldviews of design

Weltanschauung (Worldview)	Description
Problem Solving	Design can be seen as an attempt to solve a known problem, a view characterized by the beliefs that a problem exists and is identifiable and that the success of a design is related to how well it solves the problem.
Problem Finding	Design can be seen as an attempt to solve an unknown problem, implying that understanding the problem is part of the design process.
Epistemic	Design can be seen as a learning process where actions that can lead to improvements to the current situation (in the eyes of stakeholders) are discovered.
Inspiration	Design can be seen as a result of inspiration, i.e., in- stead of beginning with a problem, design begins with an inspiration of the form ‘wouldn’t it be great if....’
Growing	Design can be seen as growing an object, progressively improving its fit with its environment and purpose.

In their terms, my practice has been informed by each of these views, as appropriate to different stages of the developmental process, but in particular by Inspiration , deriving from the new opportunities that technology provided, tempered with Epistemic and Growing through engagement with teachers and learners.

The verb design in my practice is an iterative process of development, accompanied by trialling, feedback and evaluation to determine the focus for further improvement. The mutability of designs may be promoted by their expression in computer formats, which offer ready correction and change. With the advent of computer programs, many designs can be expressed in the computer language or information system directly, although not all such languages make such designs accessible. This is the domain of Learning Design (Koper 2006), where one possible benefit is

that the design may become enacted through the computer to guide a student on a learning trajectory.

Britain, in his Review of Learning Design , states that the central ideas behind learning design:

> represent new possibilities for increasing the quality and variety of teaching and learning within an e-learning context:
>
> - The first general idea behind learning design is that people learn better when actively involved in doing something (i.e. are engaged in a learning activity.
> - The second idea is that learning activities may be sequenced or otherwise structured carefully and deliberately in a learning workflow to promote more effective learning.
> - The third idea is that it would be useful to be able to record 'learning designs' for sharing and re-use in the future.
>
> (Britain 2004, 2)

Britain goes on to state in his conclusions:

> The main conclusion to be drawn from this review is that software development in this field is still at an immature stage although there are several exciting strands of development in progress. This means that whilst some software has been completed and other products are soon to be completed, few of the systems reviewed here have been widely used in practice as yet.
>
> (Britain 2004, 24)

This immaturity means that Learning Design is not territory which I have explored in any detail in my practice, preferring designs to provide infrastructure and tools for human decision making in a freer sense. I regard learning as less likely to succeed when too tightly prescribed and in its nature, a creative activity which benefits from openness in outcome rather than to be restricted to such sequences with too closely focussed learning outcomes. Re-use is rarely possible as the context, conditions and preferences of teachers and learners are so varied.

Nevertheless, in my practice the designed entities have all employed some element of computer technology to enhance learning. In my conception of design as a noun, it is a mutable specification:

> a representation of teaching and learning practice documented in some notational format so that it can serve as a model or template adaptable by a teacher to suit his/her context
>
> Agostinho (2006)

I would extend this definition so that a design may be that of an information resource, tool, activity, environment or educational organisation. In my practice, I have learned and employed a wide range skills including composition of words, graphic design, desktop publishing, video editing and computer programming. I have also tackled the design and making of computer programs, web sites, films, furniture, office spaces, online spaces and rooms to support education.

3.2.2 Design Science

Defined by Buckminster Fuller (1963), Design Science brought systematisation to the design process, and became understood as the scientific study of design (Gregory, 1966).

In the context of education, Mor explains it well:

> A design science of education should be based on a linguistic framework which offers an intermediate level of systematisation, rising above anecdotes but remaining grounded in reality. Such a framework would allow us to capture the structure of educational situations, the challenges they engender, as well as the means of addressing them, in forms which should empower learners and teachers to control their practice as much as it allows researchers to inspect it scientifically.
>
> (Mor 2010, 14)

I would extend this view and suggest that a design science of education might also encourage creativity in the attempt to transform education for the better, and argue that the analytical perspectives [A1 , A2 , A3] I present in the section Claim form part of a 'linguistic framework' to support such creativity.

3.2.3 Complexity and iteration in design

Educational designs I have engaged with have been complex and iterative, and in a research context could be considered as design studies as described by Shavelson et al:

> Design studies have been characterized, with varying emphasis depending on the study, as iterative, process focused, interventionist, collaborative, multileveled, utility oriented, and theory driven.
>
> (Shavelson et al. 2003 , 26)

The iterative view of design (the verb) is not opposed to a design process base on architectural/ engineering specification, where well known and predictive calculations can be made to find the exact dimensions and materials to create a building or bridge. Instead, the iterative view recognises the unpredictability of the design of education where people, their diversity, complexity and culture are part of the design space, not simply users of an end product. It is not enough to design a computer program which performs to specification, tests correctly and is viewed as satisfactory - in education such software is subject to the richness of human discourse, re-interpretation and creativity. In the process of iterative design, such issues can be explored and the design improved with the evidence gathered to make the most effective educational outcome in a dynamic context. When designing in collaboration, designs require shared meaning in the form of agreed theories amongst the collaborators, in order to evaluate designs and identify room for improvement - my thesis in the form of three analyses [A1, A2, A3] is intended to be a basis for this kind of practice.

3.3 Learner

The concept of learner in my work has been particularly concerned with the developmental fulfilment of the learner at all stages in a lifelong venture, that is learning for intrinsic reasons, as well as preparation for work, culture and citizenship.

3.3.1 Introduction

This section focusses on the individual learner perspective that informs my practice. The learner in my practice has been central to improving the design of materials and courses, but not without understanding the social context. Dewey convincingly argues the importance of this in his declaration of pedagogical creed:

> In sum, I believe that the individual who is to be educated is a social individual and that society is an organic union of individuals.
>
> If we eliminate the social factor from the child we are left only with an abstraction; if we eliminate the individual factor from society, we are left only with an inert and lifeless mass.
>
> Education, therefore, must begin with a psychological insight into the child's capacities, interests, and habits.
>
> Dewey (1897, 77-80)

Making sense of the individual learner - their capacities, interests and habits - has helped me to develop a model of learning, Expressive Constructivism, which operates on the foundation of the concepts and theories expressed in the following sections.

3.3.2 Learners' Knowledge

The capacities to know, decide and act are represented by learners' knowledge. Knowledge is a term that is naturally confused in meaning, between the kind of knowledge which individuals have in their mind in order to think, make decisions and perform, and that which is shared in speaking, writing and other media and used by society to coordinate meaning and action. I prefer to consider the first, mind, as primary, and intimately connected with action, as proposed by Piaget in the term schemata - systems of knowledge in the mind arising from the interplay of experience and activity (Piaget 1953). The secondary meaning, that of externalised or articulated knowledge, is not normally functionally independent of human interpretation, but may be viewed as essentially information. Piaget's argument for biological stages in the development of learner's knowledge, linked to age, is developed by Vygotsky's more fluid perspective (Wertsch 1987), where learner's capacity may be greater when supported by another, named the zone of proximal development.

In both cases, learner's knowledge is argued to be modified by on-going experiences. The Expressive Constructivism analysis presented in this dissertation simply proposes that the experience that develops learners' knowledge is more specifically the expression and evaluation of learner's own knowledge by learners themselves, with varying levels of support.

This relates closely to Laurillard's concepts of intrinsic and extrinsic feedback (Laurillard 2012, 55). Intrinsic feedback is that which is experienced through the consequences of our actions (close to the internal evaluation in my analysis [A1]). Extrinsic feedback that which is made from others' communications and observations (close to the natural evaluation in my analysis [A1]). Laurillard goes on to identify the importance of the learner's production of some representation of what they have learned (close to the natural and formal expression in my analysis [A1]) and continues with:

> The nature of "learning through production" has not been thoroughly researched, despite the importance in formal education of insisting that learners produce something to show what they have learnt.
>
> (Laurillard 2012, 57)

Laurillard does point out some attention has been paid to this in the context of collaborative learning, but her point reassures me that the analysis I have made [A1] is a useful contribution. Laurillard's Conversational Framework model of learning (Laurillard 2012, 92) is very close to the analysis I have proposed [A1], sharing many features, but its intention is to model the role of teachers, learners and peers, whereas I have focussed on the individual learner and greater simplicity to ease the designer's task.

The nature of Learners' knowledge is considered below by dividing it into facts, skills, mental models, strategies and attitudes.

3.3.2.1 Facts

In my view 'facts' are the simplest form of knowledge that enable the learner to respond to simple questions of definition. In logical terms, they represent connections between two or more atomic concepts, for example 7 times 8 is 56 connects 7, 8 and 56. Such facts are interconnected with others, such as 56 divided by 8 is 7 and thus can become metal models. They are important in that they empower higher order knowledge, but becoming less vital as we are increasingly supported by technology in the form of calculators, online dictionaries and searchable information. Performance is shown by recall or recognition of sounds, acts, definitions or simple relationships.

3.3.2.2 Skills

Skills are the standard, well-established procedures to be carried out by the learner when applicable situations are recognised. Performance is demonstrated by carrying out the procedure in front of others or by recording steps in the process.

3.3.2.3 Mental Models

Mental models are complex and dynamic relationships which can be employed to explain and predict more complex issues and may be based on networks of facts and skills. As such they are the most important form of knowledge to be improved through the expression and evaluation argued for in the Expressive Constructivism model of learning [A1] and thus are the subject of this discussion here.

My design practice has developed with the fundamental assumption that mental models (Craik 1943; Johnson-Laird 1983) are the basis of an individual's knowledge. Facts and skills could be argued to be the simplest mental models, but I prefer to identify them separately and as building blocks.

My belief in the importance of mental models to educational design is based on Donald Norman's view:

> In interacting with the environment, with others and with the artefacts of technology, people form internal mental models of themselves and of the things with which they are interacting. These models provide predictive and explanatory power for understanding the interaction.
>
> (Norman 1983a, 7)

I contend that mental models enable explanation, prediction and thus decision-making and action in a much wider sphere than Norman's focus on the interaction with technology. Nevertheless, it is in the practice of developing better user-interfaces in educational software that my journey as a practitioner started. I found that by extending the concept of mental model to embrace a wide variety of modalities (sensory modes such as sound, vision, touch) and genre (expressive modes, such as narrative, diagram, play or poem), it could provide a basis for understanding learners' knowledge in all its guises.

I accept the constructivist view, that knowledge is created in the mind of the learner by their own mental activity in response to experience and information (Kolb 1984). In my view, at the heart of this is the establishment and improvement of mental models.

Mental models are not only faulty (as they continue to develop through refinement), but also unconscious in the sense that they may be unknown and even their nature unknowable to the person employing them. Nevertheless they may provide effective capability and thus form the basis of tacit knowledge (Polyani 1966).

3.3.3 Observing mental models

I do not believe that it is fruitful, especially for the design practitioner, to spend too long identifying mental models' structural properties nor attempting to use mental models as a basis for formal prediction or explanation. In my view, the biological representation and processing of mental models, in both the network and dynamics of the neural connections in the brain or the phenomenology of the mind, is simply too complex, diverse and subtle. To add further futility (or utility if this is seen instead as a teaching strategy), the act of discovering mental models, through dialogue with learners, can change the mental model itself (Rogers et al. 1992).

Further research in this area may be ultimately successful, but is a diversion in terms of my design practice. Clarity about the neural structure of the brain may indicate useful design issues, but often on a different level than that of thinking and learning. I suggest we can only objectively deduce the

strengths and limitations of mental models by observing and analysing human behaviours, verbal utterances and written or graphic articulations - expressions. This inability to more directly observe mental models does not lead me to reject mentalism, the study of mental perception and thought processes, as Skinner might (Hill 1984, 63-87).

3.3.4 Introspection and self-report

Instead, in my design practice I have favoured a more subjective lens for examining mental models through introspection (Kind 2005), the self examination of thoughts and imagination which can support our understanding. This kind of self-report is, I believe, no more or less useful than any other evidence we gain from human behaviour, and clearly needs to be handled with care. Nevertheless, table 5 lists some examples of mental models and distinguishes between mental models (learner's knowledge) and externalised conceptual models (information).

Table 5: Examples of Mental models

Mental model	Description
Visualisation of a number line	In my own experience, I am aware that I imagine a timeline of numbers when comparing numerical values, which I suggest has grown organically as I have developed numerical understanding. The numbers 1 to 10 are arranged in a semi-circle with a slightly tighter bend after 5. Another sharp bend between 10 and 12 leads to a gentle spiral from there until 30 after which an even more gentle curve leads to 100. After 100 a final line, almost straight, leads to 1000 and beyond. Other numerical contexts such as temperature, time and calendar dates, offer other shapes to the line and with significance perceived at key points by bends - 32 degrees Fahrenheit, 100 degrees centigrade, 0 degrees Kelvin, breakfast, tea-time, midnight, December 31st/ January 1st, the centuries. These mental models help me to estimate values and relate numerical symbols to real-world phenomena and decision making. If I attempt to draw this model on paper, as a conceptual model, it soon fails, since the mental perception often transcends three-dimensional space, showing and revealing features dynamically as needed.
How do I get to the station?	On many occasions, I have travelled from a railway station to a conference venue. My ability to return to the station is based on the mental model built on the journey, which in my case is considerably richer than a turn-by-turn account of street corners. The model is used to make decisions and affords flexibility, rather than simply followed by inverting the turns made on arrival. Its representation as an externalised conceptual model might be a map, but this only captures part of a more complex 3D visualisation and relationship with a body-centred decision making procedure.

Arithmetical facts, e.g. 7 x 8 = 56, 56 ÷ 8 = 7 and 56 ÷ 7 = 8	These three number facts are combined as part of a bigger mental model for me - someone who was successful at memorising multiplication tables from an early age. An external representation would be in the form of a concept map relating the three numbers 7, 8 and 56 as nodes with directional arcs labelled with the relevant mathematical operations. The full model takes in all the factors up to 12 - in my day you learnt up to the 12 times table - and some other exceptional numbers beyond. A relationship with other number facts (70 x 80 = 5600) where other rules and patterns extend the basic multiplication table. I have no idea how this material is actually formulated in my mental model, it is recalled unconsciously, but I believe it is both parsimonious and effective for me because of its cross connections. The mental model helps me both predict and explain arithmetical results, estimate calculations and solve numerical problems. Externalised conceptual models which are often drawn include number squares, but the graphics do not make clear all the patterns and connections held in a complete mental model.
The effect of flattery	This complex mental model helps with other people's reaction to my behaviour. Through it I can predict how well received a comment about someone's performance, appearance or feelings might be, and thus choose my words carefully to achieve the effect I desire. It can go wrong and has often lead to doubt about my ability to make these judgements. It can be effective in forecasting behaviour or just as often, dissecting the reasons for upset. It is symptomatic of autism that this kind of modelling is poor. Externalised conceptual models for this can be found as narrative in literature, plays or films.
Catching and throwing a ball	The capacity to predict where a ball will be, and at what time, after being thrown by a distant person is good example of unconscious, and quite likely unknowable, mental model. Its converse and, I suggest, closely related mental model is that of throwing a ball to arrive at a particular place at a particular time. Externalised conceptual models for this capability are rare and these capabilities often remain tacit knowledge.
The Bohr model of the atom	Unlike the previous example, which was primarily about prediction, this is a mental model primarily for chemical explanation. It is a picture of orbiting electrons imagined as moons around an 'earth' which represents the atomic nucleus of protons and neutrons. It can be extended to imagine more complex orbital patterns and rules for the number of electrons at each level. Limited predictions can then be made to imagine new elements and chemical bonds between atoms. This articulation does not mean that this is exactly how the mental model is formed in the mind, but the gravitational and geometrical parallels to actual atomic forces provide a visual and visceral way to know about atomic particles, although incomplete and a fiction! An externalised conceptual model in the form of a diagram (or animated film) can be drawn - this can become a shared articulation helping to develop and align each individual's mental model.

These examples are important to me in my practice because they differentiate between the idea of mental model and that of externalised conceptual model. The latter is a shared articulation of knowledge, often in oral, written or diagrammatic form (including a map) which tries to capture the essence of mental models so as to communicate knowledge.

3.3.5 Problem solving strategies

This form of knowledge is the basis of analysis and creativity and may involve the application of mental models. I argue that the key capabilities are those of recognition, open-mindedness, backtracking and re-formulation. My own work in this area resulted in a published paper to identify the steps that the learner would need to undertake to formulate computer models (Millwood and Stevens 1990), based on the experience gained in formulating the Modus project to design modelling software:

- identifying a purpose;
- having concern for presentation and communication;
- constructing an interactive simulation;
- picturing the end-product;
- identifying elements;
- characterising elements;
- identifying relationships and
- characterising relationships.
-

3.3.6 Attitudes to learning

Learning attitudes, or dispositions, are often the 'soft' and unrecognised aspects of knowledge in the learner, and not tested directly through summative assessment. I would argue that attitudes to be developed include determination, motivation, love of subject and a concern for quality and detail. Successful learners may also be patient, optimistic and persevering (Seligman 1998). A substantial development in my thinking in relation to attitudes to learning, inspired by collaboration with Stephen Heppell, was the concept of delight. The challenge to script and present a Teacher's TV programme, Happiest Days? (Millwood 2006), was the starting point for my own delight framework An Analysis of Delight (Millwood 2008a) based on John Heron's work (Heron 1992), which I designed to explain and justify design choices in technology-enhanced education. This framework is outlined in the Methodology section on Values driving the research.

3.3.7 Summary

This view of the learner and the range of types of their knowledge helps me as a designer to identify how technology enhanced educational innovations can support learning and offer a critical framework within which improvement to designs can be made based on a static understanding of what is to be learned - the curriculum. But the dynamic processes of learning, as described by learning theorists in the next section - The Challenge of Learning Theory, provide such a rich and

diverse picture, that to be pragmatic in my design practice I began to seek simpler models that provided sufficient detail to inspire and justify design decisions, hence the genesis of Expressive Constructivism [A1] as set out in the Claim section.

3.4 The challenge of Learning Theory

For the designer, understanding the learner through learning theories can lead to a rich, diverse and contested quagmire, where the differences between concept, theory and paradigm are not well explained nor observed. This section sets out that complexity in order to explain the motivation to construct a simple constructivist model.

This concept diagram (Figure 5) and notes below are taken from the work I undertook to complete an overview of learning theory for the EU-funded HoTEL project (Millwood 2013a), intended to help technology enhanced learning innovators untrained in educational theory to make better sense of theory in order to improve their designs and the impact of their innovations.

In the report I propose that:

> Learning theory has been a contested scientific field for most of its history, with conflicting contributions from many scientific disciplines, practice and policy positions. With the continuing and disruptive influence of technology on information, knowledge and practice in all sectors of society it is no wonder that innovators, drawn to the interactive potential that computers bring to learning, are challenged by the theoretical basis for their innovations.
>
> Formal education is also a high stakes, culturally & institutionally conservative activity, which serves more than one societal purpose, including:
>
> - learner development and fulfilment;
> - child care;
> - preparation for citizenship, parenthood and retirement;
> - preparation for work;
> - selection for jobs.
>
> Even in the higher, informal and professional sectors of education, complexity of education is matched by complexity of learning outcomes which may include:
>
> - skills development;
> - knowledge acquisition;
> - improvement in strategic, analytic and creative capacities;
> - attainment of competence;
> - establishment of attitudes and values.
>
> Each of these societal purposes and these learning outcomes demand different approaches and understandings for the theorist and may develop at varying rates or found to be diverse in relation to context, location and culture.
>
> Millwood (2013a)

In these circumstances, I as a designer have had to create a theoretical position which draws from the best, yet can provide a more straightforward basis for design decision-making. This position is set out as my thesis in the Claim, and the work undertaken to analyse disciplines, theorists and

their theories helped to clearly found my thesis in a constructivist paradigm of learning - Expressive Constructivism [A1].

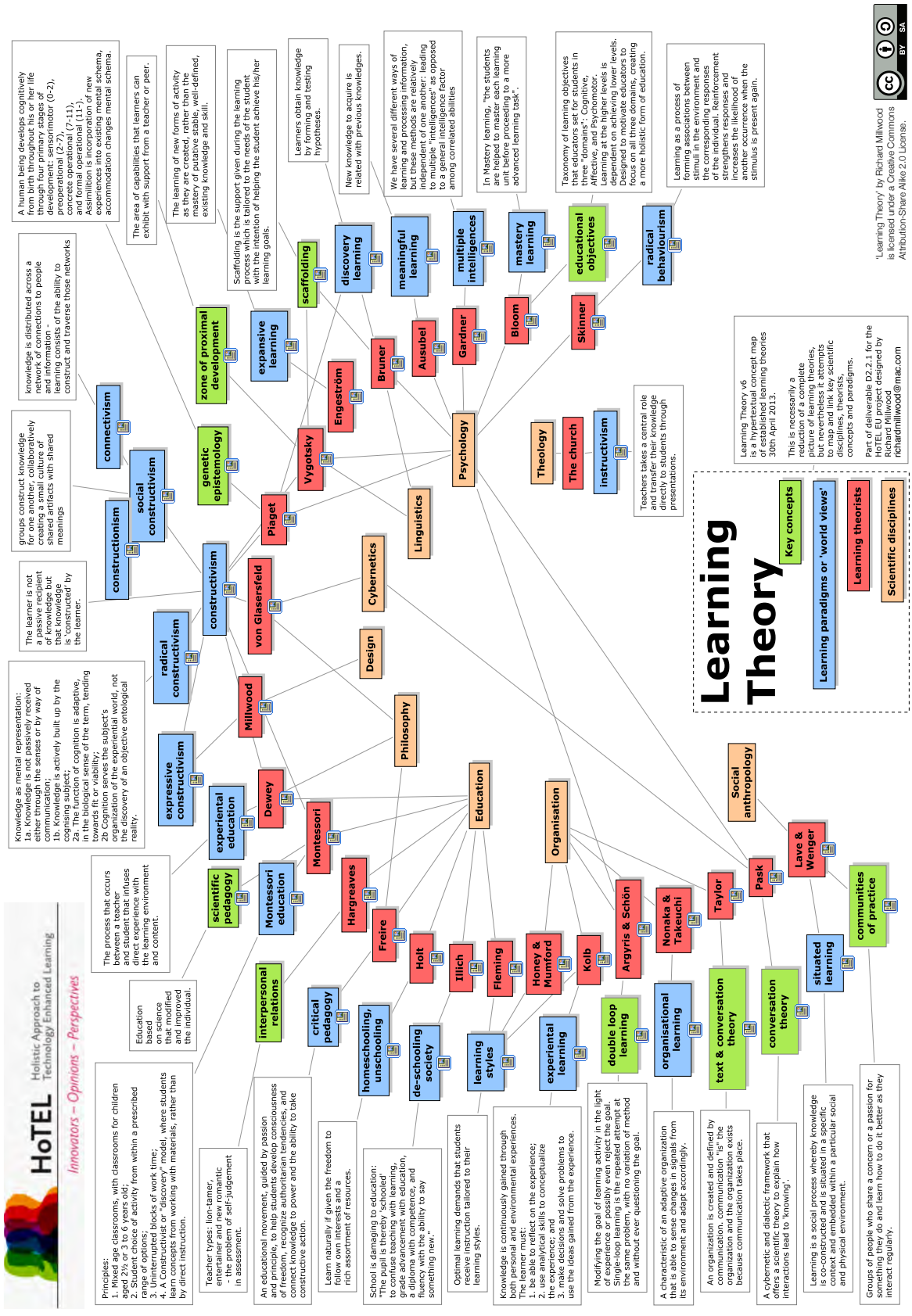


Figure 5: Learning Theory

3.5 Technology

Technology as an augmentation of human performance has been central to my design practice - for creativity, communication and content. I have been a strong advocate of Owers' ideas (2001) regarding the evolutionary symbiosis of technology and humankind, which provides a context for justifying educational design with technology.

Technology in education is often positioned as its servant, a tool to help achieve pedagogic ends already determined without technology. Although there is merit to be driven by educational needs when employing any resource, this position can be questioned in the light of technology's relationship with humankind more generally. As Stan Owers pointed out in his PhD study:

> The literature research confirmed that technology is as old as humankind. The foundations of technology resides in our imaginative capabilities as toolmakers. Humankind has always used tools, and recently technologies, as extensions of itself. Tools and technological evolution have been constant companions to the evolution of humankind.
>
> (Owers 2001, abstract)

Owers' point of view, that technology extends humankind and has been a constant companion in evolution, suggest that we look for extension to education through technology, not simple service to education. Educational software has the capacity to support new pedagogies, and this has been recognised since the 1970's as evident in the analysis offered by McDonald et al (1977), as tabulated by me in table 6 (Millwood 1987), to identify the computer's potential contribution through three paradigms: instructional, revelatory and conjectural.

McDonald et al (1977) also propose a fourth paradigm, the emancipatory paradigm, in which the key concept is the reduction of inauthentic labour, but this does not occur in isolation to the three paradigms initially defined, since each reduces such labour to some extent.

McDonald et al's analysis was hugely influential in the 1980s, often cited by students exploring the possibilities of technology, but as time passed and new capabilities of the technology available were developed, I have found the need to extend and clarify the potential contribution made by technology in learning as set out in the Claim section in the analysis How can technology enhance learning? [A2].

Table 6: Educational Paradigms for Computer Assisted Learning

	INSTRUCTIONAL	REVELATORY	CONJECTURAL
Key concept:	Mastery of content.	Articulation and manipulation of ideas and hypothesis-testing.	Discovery, intuition, getting a 'feel' for ideas in the field etc.
Curriculum emphasis:	Subject matter as the object of learning.	Understanding, 'active' knowledge.	The student as the subject of education.
Educational means:	Rationalisation of instruction, especially in terms of sequencing presentation and feedback reinforcement.	Manipulation of student inputs, finding metaphors and model building.	Provision of opportunities for discovery and vicarious experience.
Role of computer:	Presentation of content, task prescription, student motivation through fast feedback.	Manipulable space/ field/'scratch pad'/ language, for creating or articulating models, programs, plans or conceptual structures.	Simulation or information handling.
Assumptions:	Conventional body of subject matter with articulated structure; articulated hierarchy of tasks, behaviouristic learning theory.	Problem-oriented theory of knowledge, general cognitive theory.	(hidden) model of significant concepts and knowledge structure; theory of learning by discovery.
Idealisation / Caricature:	At best, the computer is seen as a patient tutor; at worst it is seen as a page turner.	At best, the computer is seen as a tool or educational medium (in the sense of milieu, not communications medium); at worst, as an expensive toy.	At best, the computer is seen as creating a rich learning environment; at worst, it makes a 'black box' of the significant learnings.

3.6 Education

The concept of education is here concerned with the aims, objectives & values, the organisations, processes & culture of the instruments & institutions that society has formulated to address the its needs to educate lifelong learners.

The ideas of Hargreaves (1975) concerning the interpersonal relationship between teacher and learner, Deming (1982) regarding the pursuit of quality and the cybernetics systems theory from Beer (1985) and Ashby (1956) have been influential and are discussed in this section.

3.6.1 Teacher and Learner

In the early years of my design practice, I focussed on learning in the microcosm of the individual learner. Within this context, my attention was on the use of the computer rather than the wider process of education signified by the classroom. When first registering for PhD in 1986, I was invited to produce a qualifying essay (Millwood 1987) which I based on teacher stereotypes identified by Hargreaves (1975, 162-200) and set out in table 7.

This diversity of aims, objectives and values devised by Hargreaves was new for me, not only as a perspective on education but in how the design of technology enhancements might take account of the context of use and indeed support the aims of such de-schoolers as Illich (1970) and Holt (1976). In my essay (Millwood 1987) I made a connection between McDonald et al's (1977) paradigms for computer assisted learning and Hargreaves' (1975, 162-200) teacher stereotypes that helped me understand why teachers might propose designs in different ways according to the predominant teacher stereotype in their practice.

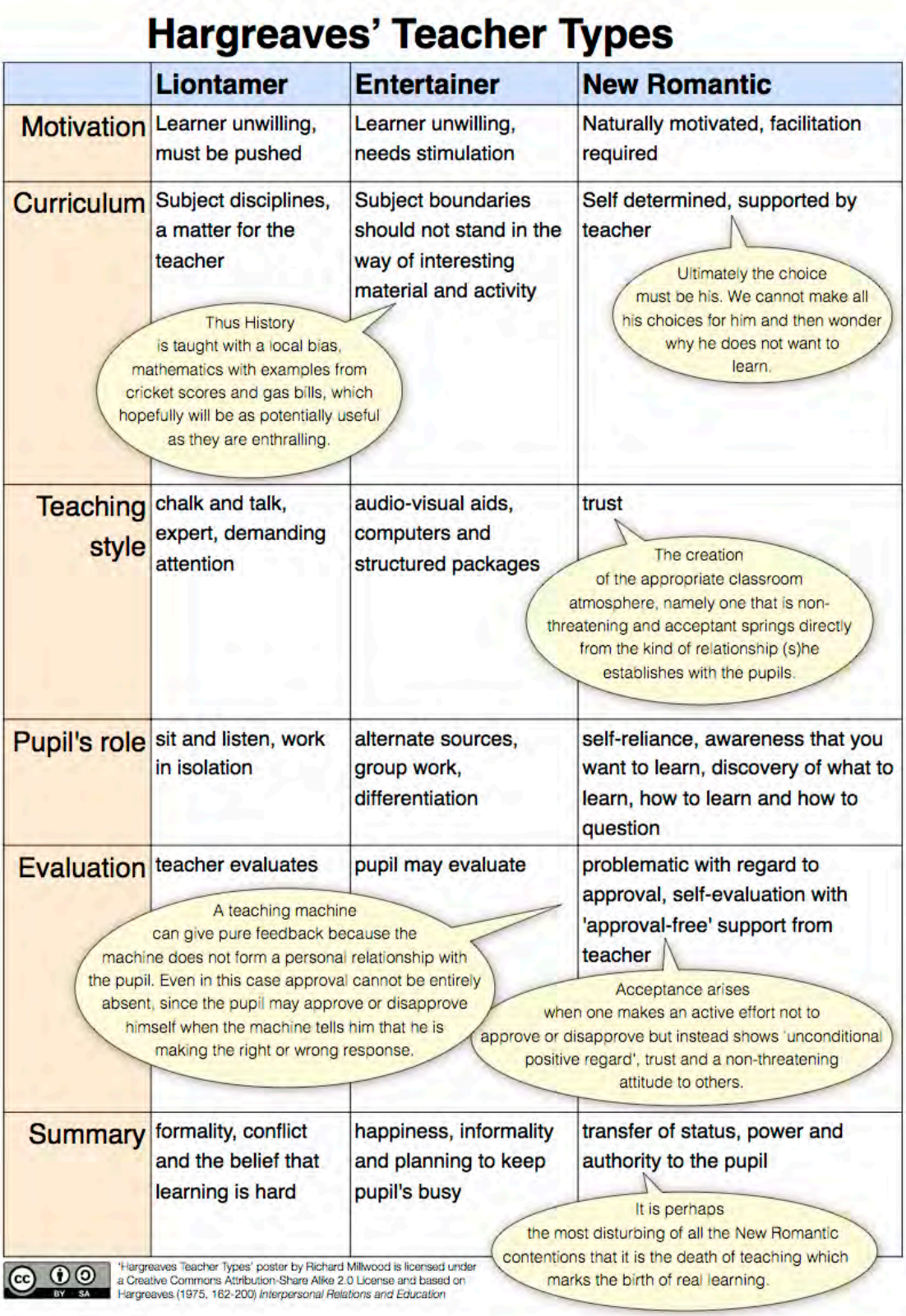
This analysis must be treated with caution as it does not aim to categorise teachers, but as Hargreaves points out:

> "the reader must remember that these are 'ideal types' in Weber's sense of the term."

and that:

> "it would be a disastrous mistake to think that the teaching profession can be divided neatly into three groups. Whilst some teachers may be much closer to one type than to others, many teachers are a complex mixture of the three types."
>
> (Hargreaves 1975, 163)

Table 7: Hargreaves' teacher types



3.6.2 Educational quality and improvement

In producing the CD-ROM for the 'Business of Quality' in the Renaissance Project, an interactive multimedia account of Deming's theories for improvement in manufacturing and business (Deming 1982), I learnt about the notion of quality and how it can be monitored. What came as a revelation was the idea that customers should be delighted, not simply satisfied in order to succeed in competition with other companies. I found these ideas transformative in my own thinking about educational institutions and their improvement, and connected to the social sciences notion of an action research approach with the plan–do–check–adjust cycle. It gave foundation to my later work to design education organisations to be profoundly learner centred (TeacherNet UK; [P9] Ultraversity Project).

3.6.3 Educational community and variety

The development of educational organisations online presented many new challenges to the designer, and tacitly these were solved by encouraging online learning community to develop where peers expected to learn from each other as well as from content, experts or tutors. This thinking became clearer when contrasting the [P9] Ultraversity Project and the [P10] Inter-Disciplinary Inquiry-Based Learning (IDIBL) project. The first was considered highly successful and the second struggled to make headway. By applying the concept of 'variety' in the context of Cybernetics (Beer 1985; Ashby 1956), it was clear that the successful design benefitted from the absorption of variety in student states by inviting them to build relationships of mutual respect and support with each other. This meant that the facilitation team, tasked with leading the community, were able to manage the variety that remained without being swamped with so many diverse questions and problems (Millwood and Powell 2011).

3.6.4 Educational design

In my practice, applying the ideas of design to education was initially tacit in nature, but later influenced by the explicit principles developed by theorists such as Gagné (1985). These are based on an analysis of instructional events (and corresponding cognitive processes):

- gaining attention (reception)
- informing learners of the objective (expectancy)
- stimulating recall of prior learning (retrieval)
- presenting the stimulus (selective perception)
- providing learning guidance (semantic encoding)
- eliciting performance (responding)
- providing feedback (reinforcement)
- assessing performance (retrieval)
- enhancing retention and transfer (generalization).

But these events are focussed on what the teacher should do, with the assumption of Hargreaves' 'liontamer' or 'entertainer' stereotypical style (Hargreaves 1975, 162-200). It also focusses on the

lesson, rather than the complete scope of educational experience for the learner. This led me to analyse education from the perspective of the learner, which is the subject of the analysis The Learner at the Centre [A3] to be found in the Claim.

4 Claim

I have been designing, developing and researching educational materials, contexts and practices based on computer technologies since 1978, and as a practitioner in this field, sought to design each more effectively to improve education. In that time I have researched widely across multiple disciplines with a learner-centred focus. My claim for PhD by Practice begins by explaining the story of my developing knowledge, continues with the selection from my portfolio and then sets out my thesis in the form of three analyses to support the design of learner-centred technology-enhanced education.

4.1 Introduction - from tacit to explicit knowledge

This section outlines the story of my developing knowledge and links it to my thesis. It explains the origins of the thesis in the development of tacit knowledge in practice and its transformation to explicit knowledge.

The eleven items of practice linked to this claim are denoted by the suffix [Px], and the three analyses which form my thesis by the suffix [Ax].

4.1.1 Teaching

I have progressed from an individual enthusiastic and creative teacher of Mathematics and Computer Studies at Scott Lidgett School, taking part in developing educational software and practice as a member of the Microcomputers in Computer Education (MICE), to a researcher in the Computers in the Curriculum Project at Chelsea College London [P1] and leader of innovation in education as senior lecturer in Ultralab at Anglia Polytechnic University [P4], taking a full part in a developing research community.

My early work concentrated on leading the improvement of the design of individual pieces of software for addressing challenging learning in the school curriculum, expressed in a design and development tool the Procedure Library [P3].

4.1.2 Curiosity about learning

An interest in user-interface design and mental models through the London Mental Models Group [P2] provided a basis for analysing individual learning based on Norman's ideas (1983a, 1983b). My work on new multimodal learning based on multimedia technology in the Renaissance Project created a foundation for an Expressive Constructivism model of learning [A1], and an account of how technology enhances such learning [A2], both created to inform design practice.

4.1.3 Commitment to Learner-Centred Education

In this period my increasing awareness of the wider context of education informed a holistic and systemic approach to large-scale action research addressing the development of new systems of learner-centred education online as a Senior Lecturer in Ultralab [P4], and particularly in the projects Ultraversity [P9] and Inter-Disciplinary Inquiry-Based Learning [P10]. Alongside this work, I

focussed in on participation, creativity and reflection in learning through a sequence of projects. For participation I helped develop methodologies for self-translation of software to local language and culture [P5] and the development of a new toy in the Étui project [P6]. For creativity I investigated user-generated content for mainstream television in Input CBBC [P7] and advised the QCA on creativity with technology [P8] benefitting further the articulation of the Expressive Constructivism model of learning [A1]. Finally, the exposure to education as systems helped me formulate the third analysis of the learner at the centre of education design [A3].

4.1.4 Leadership and tacit knowledge

My increasingly responsible rôles as a teacher, software developer, media designer, team leader and director led to the development of a broad and deep, but tacit knowledge of the factors which lead to effective design methods and criteria for improving design quality in iterative design cycles. A substantial number of conference presentations, in-house workshops and teaching, at both practical and academic levels, forced me to explain this in greater detail and thus refined my tacit knowledge.

4.1.5 Theory and constructivism

Argyris and Schön (1978) introduced two ideas of theory of action: the concepts of theories-in-use and espoused-theory. Theories-in-use can be seen as driving actual behaviour and driven by tacit knowledge. Espoused-theory is that which is used to explain when challenged, but may not be actually followed in practice. The articulation of these design factors, criteria and models of learning & education in the three analyses [A1], [A2] and [A3] is a development from theories-in-use. One can arguably improve effectiveness (Argyris and Schön 1978), by making a closer fit between theory-in-use and espoused-theory through reflection, and so an important facet of this thesis is that the analyses developed have been tested, reflected on and improved in practice to enhance their effectiveness and validity.

Furthermore, a recently created critical overview of learning theory for non-academic innovators in a report for the EU project Hotel [P11], has helped to locate this thesis firmly as a constructivist approach.

4.2 Eighties

I took up my first professional research post in 1980 to design and develop educational software. This period saw a progression in my practice from a focus on technology to a concern for design & pedagogy and my first attempt to engage with doctoral study.

Table 8: Selected items from the 1980s

Portfolio reference	Aim	Contribution	Originality, Impact and Importance	Evidence
[P1] Researcher in the Computers in the Curriculum Project at Chelsea College London	To establish design leadership for teams of programmers developing computer assisted learning for secondary age students.	I designed and developed many educational programs, guidance documents, course materials and developed analytical models for evaluation of user-interfaces. I exercised nationwide team leadership and national leadership in educational software interoperability. My part: 100%	The Computers in the Curriculum project, first established in 1973, was one of only a very few world-leading curriculum development projects in its time to create brand new computer assisted learning materials based on a 'revelatory' approach using simulations (Millwood 1987, 8). There were very few predecessors in the schools sector. It was funded for the first half of the eighties by the UK government funded Micro-electronics Education Programme, absorbing a large proportion of its budget. The materials were widely published internationally through Longman, BBC and others. The work covered a wide range of subjects in the secondary curriculum. (Watson 1987)	The project impact on the UK and internationally is evidenced in the Computers in the Curriculum Newsletter No. 6 (Donoghue 1984) Which shows the breadth of engagement, size of the enterprise and the impact being made at conferences worldwide.
[P2] London Mental Models Group	To discover new perspectives on the mental models of learners with regard to their use of technology as a tool for developing such models.	I participated and contributed ideas to seminars considering models of learning with technology. My part: 5% (project led by the late Joan Bliss)	The work to integrate an educational approach to technology, learning, artificial intelligence and mental models was unique, recognised by an Economics and Social Research Council grant for the 'Tools for exploratory learning' project (Bliss and Ogborn 1989) and peer-reviewed publications. It had impact on the design of new modelling software and importance in raising the level of debate at an early stage in the maturation of technology in education amongst the educational research community in London.	Joan Bliss' obituary (Ogborn 2011) contains testimony to the significance of this group.
[P3] Procedure Library	To improve standards of interoperability in the design of educational computer programmes.	I designed the set of procedures and functions, wrote the BBC BASIC and Pascal code and technical guide and co-authored the design guide which included the creation of the diagram and analytical explanations. My part: 50% (with David Riley)	The design, code and analysis were new, based on lessons learnt over seven years of using a BASIC subroutine library and the best of graphics routine library literature (Newman and Sproull 1989). The impact and importance was on the development and design of educational software by the Computers in the Curriculum team.	My leadership is documented in the Computers in the Curriculum project publications, including Newsletter 6 Computers in the Curriculum Newsletter No. 6 (Donoghue 1984).

In 1980 I sought a position as a university researcher to develop educational resources. I was appointed as the first developer for the Computers in the Curriculum Project [P1] at Chelsea College, University of London. Over the decade I became a project leader in software development, an author of design guidelines [P3] for the team and a teacher educator involved in teacher training. I was responsible for the design and development of many educational packages based on computer simulations, working with teams including practising teachers to offer advice on the pedagogical and practical design issues. In researching human computer interface issues, I was strongly influenced by Donald Norman's models of user-centred design (1983b). These proved practical as applied theories in my everyday work and formed the basis for my first ideas for a simplified model of the learning process, later developed as Expressive Constructivism [A1]. In this decade I joined the ESRC funded London Mental Models Group [P2], led by the late Professor Joan Bliss and Professor Jon Ogborn, and planned to conduct a PhD supervised by Professor Paul Black to focus on modelling using computers. I took part as a lecturer in the development of a diploma course to retrain teachers for Computer Studies and finally as a half-time lecturer in Mathematics Education [P1]. I co-directed the Modus project to develop computer modelling software for learners to create their own simulations, resulting in the development of Expert Builder and Model Builder software. I acted as Research Fellow on interoperability in educational software for the national Microelectronics Education Support Unit, creating several reports and peer-reviewed publications and was a member of the Software Advisory Group for the BBC Domesday Project. As pointing devices, audio, picture, video and the CD-ROM, became available, I led the technical production and contributed to the educational design of interactive multimedia for higher education in mathematics, environmental science, theatre studies and business studies for higher education. In this decade I began to be invited to academic conferences as a speaker and to take part in international seminar and workshop activity as co-tutor.

4.3 Nineties

In 1990 I stepped back from an academic research focus and returned to creative practice, developing interactive multimedia materials to distribute on CD-ROM, albeit as a senior lecturer in the education faculty of Anglia Higher Education College. The decade saw the rise of Ultralab, of which I was an informal deputy head, growing from half a dozen to over fifty staff. My practice saw a move from software development to medium-scale action research in pilot projects relating to online communities. I also helped develop an online Masters degree and begin supervising doctoral students.

Table 9: Selected items from the 1990s

Portfolio reference	Aim	Contribution	Originality, Impact and Importance	Evidence
[P4] Senior Lecturer in Ultralab at Anglia Polytechnic University	To develop a collaborative team approach to the design & development of new technology in learning.	I was a designer, developer and technical producer of many projects, a lecturer in ICT in Education and a designer and developer of a Masters level course. My part: 25% (with Stephen Heppell and others)	The Ultralab team was distinctive in its structure, ethos and practice, developed on values and principles of inclusion and participation. Its ethos was to directly change the world of education with its action-research innovations and thought leadership. Its work influenced national policy in the UK through Ultralab director Stephen Heppell's leadership in the Stevenson inquiry and beyond through membership of governmental advisory bodies and a regular diet of high-level keynote presentations at conferences.	The Stevenson Report (1997) and my membership of the UK government's Learning Software Task Force. Further evidence from the full portfolio online: Moscow Modelling Colloqium, EW-ED '94, MHVR '94, WCCE '95, EUROCALL '95, Mexico's Ministry of Education Conference, Jiansu Province People's Republic of China, TeacherNet UK, Learning Software Task Force
[P5] Translating software: what it means and what it costs for small cultures and large cultures	To clarify the importance of designing in opportunity for users to localise educational software to suit their own cultural and linguistic environment and thus enhance regional and international uptake	I helped design the software methodology for translation and the implementation of it in the 'Work Rooms' software as well as co-authoring the paper. My part: 20% (with Dai Griffiths, Stephen Heppell, Sam Deane and Greta Mladenova)	The practice and paper was novel in education at that time and the conceptual thinking was only just making impact in the software operating systems world. Its importance is seen in the way modern software is now developed and content management systems such as Plone have been developed to manage translation as a matter of course.	The paper was published in Computers in Education and cited regularly, most recently in 2014.

[P6] Étui	To research & develop a toy for use by early learners to encourage learning about learning.	I acted as co-developer of the project's ideas about meta-level learning, mentor to the project leader and other personnel, researcher in classrooms and disseminator of the progress and outcomes. My part: 20% (with Andy Simpson, Dai Griffiths, Stephen Heppell and Kris Popat)	The project was unique for its design of a mysterious toy which did not represent existing creatures in order stimulate wonder, inquiry and imagination. As part of the i3 research network, it was shared widely to the European research community and generated much debate about early years learning with technology.	Étui was disseminated at the conferences in 2000 and 2001 of the EU-funded Future and Emerging Technologies i3 network and at an invited workshop titled Children as Participant Designers at FutureLab's inaugural conference Contagious Creativity in June 2002.

In 1990 I joined Professor Stephen Heppell to form a new research centre, ultimately called Ultralab [P4]. Over seventeen years I offered practical, analytical and evaluative guidance to this large and geographically distributed team, offering research leadership and developing collective knowledge, procedures, values and attitudes for the development of delightful learning approaches.

Early in this decade Stephen Heppell and I began collecting materials to form a National Archive of Educational Computing and we were funded by the National Council for Educational Technology to employ Greta Mladenova to organise the materials

I continued development of new interactive multimedia CD-ROM materials, taking responsibility for production of published learning resources for Teacher Education in the Apple funded Renaissance Project . The possibility to distribute globally and the development of new materials using Apple's HyperCard led to a realisation that we could allow for adaptation to local culture and languages by the teacher and this became the subject of a published paper, Translating Software: what it means and what it costs for small cultures and large cultures [P5].

The predominant research approach of Ultralab became applied and action research, creating small and large-scale actions involving education in formal and informal contexts. I helped formulate the conceptual framework, manage development and analyse findings in many projects including a longitudinal study of online community as a learning tool Learning in the New Millenium, the University for Industry pilot Online Learning Network, the teachers' informal continuing professional development online community TeacherNet UK and the creation of a new toy for pre-school meta-level learning, Étui [P6].

This decade saw a heavy load of masters teaching, conference and workshop presentation, which gave me the opportunity to refine analyses of learning and education [A1, A2, A3] and develop them further based on the feedback from audiences and colleagues.

4.4 Noughties

In 2000, Ultralab undertook the Talking Heads project with over one thousand head teachers joining an online community of practice, thus marking a move towards large-scale action research. Later in this decade I took on the leadership of Ultralab, participating and overseeing the development of Ultraversity - an innovative online work-focussed degree programme - and later moved to the University of Bolton to help create a university framework based on Ultraversity's success.

Table 10: Selected items from the 2000s

Portfolio reference	Aim	Contribution	Originality, Impact and Importance	Evidence
[P7] Input CBBC	To design the support web site to explore the potential for students' creativity with video to be broadcast.	I took the role of co-leader at Ultralab developing the key values, participant action research approach and philosophy, working with the CBBC Future TV section at the BBC. I took on the visual and information design challenge of presenting templates and guidance in a child friendly web-site whilst maintaining a connection to the CBBC's visual style. My part: 25% (with Matthew Eaves and others)	The project was quite new for a national broadcaster to take a serious view of children's digital creativity. Its impact was on the BBC itself in informing its future policies and confirming the research outcomes from earlier Ultralab projects.	The final report (Derrick 2003) was edited by Cathy Derrick, a senior director within the BBC and was circulated to her colleagues to inform them in making sense of user-generated content by young children.
[P8] QCA - An Investigation Into Pupils' Creativity Across The Curriculum	To clarify criteria that explain how technology enhances creativity in learning.	I joined meetings to discuss and then write a contribution to the committee's report, the 'Features of ICT' section outlining how technology can enhance creativity. This contribution later became the basis for my analysis How technology can enhance learning [A2]. My part: 20%	This was a synthesis of my original thinking and other sources including my experience as a designer in discussion with many others. This was newly articulated in print by me for this consultation and adopted by this national advisory body as part of a taxonomy for advice on future curriculum thinking nationally.	The brief, my report and the taxonomy are included in the portfolio.

[P9] Ultraversity Project	To design and develop a new work focussed online university experience to suit 'those for whom traditional university did not fit'.	Initially, as part of a small team, I developed the documents for validation and designed strategy and materials for recruitment in 2003. I then had oversight of the direction of the Ultraversity Project in my role as Head of Ultralab from 2005 to 2007. I frequently took a practical developmental role, creating and designing resources, infrastructure, marketing, research and team collaboration as well as a refining a theoretical stance to champion the values and philosophy of the project. 20% (with Stephen Heppell, Stephen Powell and many others)	This project combined unique elements into a completely new fully online undergraduate opportunity. Its impact was felt deeply on the student's lives and on the researchers who made it possible. It influenced a wider academic community that drew inspiration from its success, and continues to be the subject of much interest today as well as a current course at Anglia Ruskin University. Its importance was recognised by newspapers and government ministers at the time. The project helped me enhance the analysis of The Learner at the Centre [A3] in this profoundly learner-centred design.	The video and transcripts of the student's own words included in the portfolio evidence the impact on their lives. An account of the project was published in the journal Interactive Learning Environments (Powell , Tindal and Millwood 2008) The Centre for Recording Achievement recognised the contribution and invited me to keynote at their seminar to celebrate 10 years of the patchwork text in which I presented an early version of my analysis of How can technology enhance learning [A2]. A letter from Chris Smith MP outlines the recognition from government. (Smith, 2002).
[P10] Inter-Disciplinary Inquiry-Based Learning (IDIBL)	To design and develop a whole university framework for work focussed learning.	My role was of co-developer, working closely to establish aims & values, design the curriculum, seek validation, organise, teach & mark work, operate quality mechanisms. I also designed the web site and fliers for marketing, sought meetings with stakeholders to market the course directly, worked with staff to disseminate ideas within the university, undertook research to establish evidence and co-wrote academic papers and made presentations at conferences. My part: 25% (with Stephen Powell and others)	The project was based on the experience of Ultraversity, but broke new ground by taking a whole university framework approach. It led to wholehearted adoption by some colleagues, whilst others appropriated parts of it for other courses. Its importance was in recognising the conditions under which work-focussed learning could prosper.	The impact of cybernetic theory (Beer 1985) on finding explanations for design success and failure in systems of education was published in the journal Campus-Wide Information Systems (Millwood and Powell 2011).
[P11] Report on good practice of innovative applications of learning theories in TEL	To clarify the accepted learning theories and explain their connection to theorists, disciplines and paradigms.	I exercised analytical and visual design skills in the construction of the conceptual diagram and contributed the statements about the complex, contested and dynamic nature of learning theory. I also tidied up and commented on the stakeholder analysis for innovation designers. My part: 80%	This work includes a new synthesis of key theorists and their ideas, highlighting disciplinary background. It has been widely reported as part of the Hotel EU project and achieved widespread dissemination and impact. It is intended to address an EU identified problem of educational technology innovators who are actively developing without a full understanding of the scope of learning theory and its problems in relation to technology.	The report is a deliverable of the EU funded HoTEL project (Millwood, 2013a). Widespread dissemination and impact is evidenced by the commentary on my blog (Millwood 2013c) and a number of adaptations and translations into other languages.

The new millenium saw a change in Ultralab, and my practice, from medium to large scale, national and international projects beginning with the headteachers' online community Talking Heads / Virtual Heads, the development of learner's creativity through multimedia technology for Ultralab's Summer School project and the Children's BBC Input BBC pilot [P7], and many more.

In this period I was invited as consultant to many organisations, but most significantly, to the Qualification and Curriculum Authority's panel to identify the role of technology in creativity and learning [P81]. This work was founded on a more mature form of my learning model of Expressive Constructivism [A1] and helped me to clarify the role of technology in learning [A2]. I was also invited to take part in two Teachers' TV programmes the first relating to innovation in assessment and the second, School Matters - Happiest Days?, to 'delight' in learning related to well-being in school education.

In the middle of this decade I took over as head of Ultralab for two years before joining the University of Bolton in 2007 to further develop Ultralab's ground-breaking Ultraversity project [P9] as the Inter-Disciplinary Inquiry-Based Learning project [P10].

At the same time, I founded my own consultancy company, Core Education UK, and continued to find national and international organisations, including the Qualifications and Curriculum Authority, the Improvement and Development Agency and UNESCO, willing to employ me for my analytical perspectives [A1, A2, A3], which of course helped them to be tested and refined.

This most recent period permitted substantial reflection, analysis and articulation of ideas through the European Project HoTEL (Millwood 2013a), peer-reviewed publications (Millwood 2014) and enabled the development of this PhD by Practice.

4.5 [A1] Expressive Constructivism

This model was developed to explain how learning works dynamically in terms of the cognitive activities of expression (what you do to communicate an idea) and evaluation (deciding if the idea is 'right').

4.5.1 A basis for a pragmatic learning theory

The iterative process of production of expressions and their evaluation (described in detail below), I contend, is a model of learning that helps the educational designer make effective decisions. This is achieved by examining their designs using technology to consider how they support either, or both, expression and evaluation. This way of looking at learning was first inspired by the analysis of a single interaction (Millwood and Riley 1988), after (Norman 1983b), extended by a reduction of the four stage cycle (Kolb 1984) and supported by the radical constructivist perspective (von Glaserfeld 1995).

Von Glaserfeld viewed:

> Knowledge as mental representation:
>
> 1a. Knowledge is not passively received either through the senses or by way of communication;
>
> 1b. Knowledge is actively built up by the cognising subject;
>
> 2a. The function of cognition is adaptive, in the biological sense of the term, tending towards fit or viability;
>
> 2b Cognition serves the subject’s organization of the experiential world, not the discovery of an objective ontological reality.
>
> (von Glaserfeld 1995, 51)

The expressive constructivist model holds that expressions are made continuously as an innate activity of the human condition - as if there were an internal 'fountain' of mental and physical expressiveness. Sometimes such expression is driven by internal motivation and at other times by external stimuli and contexts including social situations, and it can even be argued that it encompasses the imaginative, information-processing basis of perception, which far from being a passive act, can be seen to be a constructivist response in the mind to the raw data arriving at retina, eardrum, inner ear, skin, muscle, mouth and nose (Marr 1982, 329-332).

Similarly the evaluation question, 'is it right?', is frequently experienced (but not necessarily linguistically) as we wonder whether we have understood or articulated well and thus struggle for clearer and better expressions.

4.5.2 Validity and reliability for the practitioner

As a designer, this model has supported my practice by focussing my attention on how to make expression more creative and evaluation more powerful, and has been refined through regular exposure in conference settings. Laurillard's concept of "learning through production" is closely related and it is interesting that Laurillard contends "that this has not been thoroughly researched" (Laurillard 2012, 57). So the model of expressive constructivism relies on the literature cited above and my own experiences and observations in practice for its limited validity and reliability. Nevertheless I have found the analysis to work, and have observed and filmed the expression/evaluation loop in practice, as evidenced in these films transcribed below of children playing at the computer together and engaging in exploratory talk as defined by Wegerif and Mercer (1997):

Figure 6: An example of expression and evaluation in conversation

In this example (Figure 6), Sasha is expressing his thinking about the way the game works explicitly using natural language to his brothers. After several turns through the loop re-expressing on the basis of his own evaluation listening to his own words (although seeking the others' evaluation), eventually his brother evaluates his words.

> Patrick - I'll die if I go down there!
>
> Sasha - Like getting damaged. Getting all the way damaged do you mean? Getting damaged.
>
> Sasha - Do you know when you die? You die when you get all damaged, is what it means, when it all gets red or the green turns into red.
>
> Sasha - The red is damage and the green isn't damage. Do you understand?
>
> Sasha - When you get all damaged then you die, is that right Patrick?
>
> Patrick - Yes, yes that's right.

Figure 7: An example of meta-level learning in conversation

In this second example (Figure 7), Sasha explains how he came to know about the game by repeatedly playing a section. This simple meta-level learning shows that he knows something more than the game, that he is aware of his own processes of learning.

> Sasha - That's right, when you get down there you can just go from there and then straight down to there without a single damage.
>
> Sasha - And do you know how I know that?
>
> Sasha - Because I tried it several times - that's how I know.
>
> Patrick - That's very good, thanks Sasha!

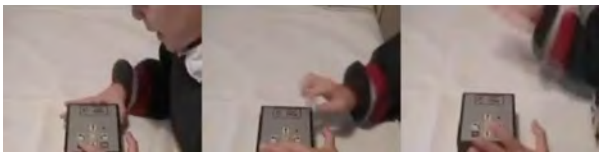


Figure 8: An example of expression, constrained by programming, and evaluation by computer performance

In this third example (Figure 8), Sasha uses the computer (a small robot) to evaluate his expression of the algorithm for making a zig-zag path like 'steps'. He is constrained to simple statements - move forward, turn left 90˚, turn right and start. He enters the algorithm into the robot and then sits back to watch its execution. If there is a mistake in his expression, it will be indicated by unexpected behaviour by the robot, thus offering a clue to the correctness of his algorithm and mental model. The opportunity to repeat this experience, and make sense of his ideas without interpersonal judgement can provide a useful learning opportunity and also a platform for further engagement with peers or adults.

4.5.3 Types of Expression and Evaluation

In table 11, figure 9 and table 12, the following types of expressions and evaluations are proposed: internal, natural and formal, each overlapping and extending the other:

Table 11: Types of Expression

Internal expression	Natural expression	Formal expression
Thinking a thought in response to listening, watching or reading. This kind of expression is thought - made, frequently, but not exclusively, in the form of internal linguistic statements and arguments. Other forms include the imagination of bodily acts, the visualisation of scenes statically and dynamically or the feeling of moods.	*Speaking, playing, performing or doing. These expressions are made outwardly and form part of a communicative act to others (or possibly to oneself, if thinking or acting 'aloud'). There is an extra demand on expression to be coherent, meaningful and effective - some preparation in thought is demanded and in this sense, natural expressions overlay internal expressions, but despite 'natural' linguistic forms, something of the richness of thought may be lost in articulation.*	*Writing, drawing, proving, planning or computing. Formal expressions use visual symbols, formalisms, syntaxes and grammars whether in written language, diagrammatic convention, logical argumentation or in programming vocabulary. There is a further demand placed on the individual making such expressions, that of complying with the formalism. As before, formal expressions overlay the internal and natural expressions and at times may be hard to distinguish.*

Figure 9: The expression / evaluation loop

As expressions are made, they are evaluated in order to decide of they were 'right':

Table 12: Types of evaluation

Internal evaluation	**Natural evaluation**	**Formal evaluation**
Does it make sense to me? This is carried out in the mind, considering the expression's quality through processes of recalling memories, analysis and enacting mental models. A major part of this internal evaluation is the imagined response of others to the expression or the applied logic of formal systems, thus anticipating the natural and formal evaluations.	*Do other people understand me?* In addition to one's own thoughts an expression may have a response from another, a group or an audience. In the best cases new challenges may be encountered or suggestions for improvement offered. Moral support for continuing the cycle is also possible in natural evaluation.	*Does the computer do what I expected?* If the expression has been articulated using formal systems, an evaluation can be carried out if the expression is 'executable' - enacted by computer in the most extreme case or performed by other people in the less formal case of recipe, musical composition or play script.

Whichever kind of evaluations are employed, new expressions are generated - often with improvements in areas identified by evaluation - and the cycle continued until satisfaction or distraction intervenes. It is my belief that this cycle leads to the improvement of mental models, whether they are of the simplest of factual relationships or the richest of human behavioural situations.

The expression / evaluation model, which I have termed Expressive Constructivism, has been the basis for decision making and a source of directions for improvement in design practice to consider how technology can enhance learning since 1986.

4.6 [A2] How Can Technology Enhance Learning?

Published as a poster in June 2012, this analysis was the culmination of years of developing understanding. It proposes features of the use of computers mapped on to the expressive constructivism model of learning, thus detailing ways in which technology can enhance learning.

The expressive constructivism model of learning directs my attention towards the learner as an active, creative individual who is best served by tools for expression on the one hand and by tools for evaluation on the other.

This notion forms the basis of the following analysis in Figure 10 of key features of technology (the terms in the speech bubbles) that might enhance expression and evaluation.The text connected by dots to each bubble serves to explain the feature.

By asking whether a design for use in education exploits these features, we can evaluate design proposals or consider what might be missing when a technology does not seem to work well. The analysis also acts as a framework for decision making when comparing alternative technology choices for their likely effectiveness in learning situations.

4.6.1 Affordances

These features of technology are closely linked to the concept of 'affordance' (Gibson, 1986) in the context of an animal and its environment.

Hammond (2009) explains and critiques Gibson's ideas and analyses the way in which many authors have attempted to use this concept to make sense of the use of technology in education. Hammond offers the following definition:

> [an affordance] is the perception of a possibility of action (in the broad sense of thought as well as physical activity) provided by properties of, in this case, the computer plus software. These possibilities are shaped by past experience and context, may be conceptually sophisticated and may need to be signposted by peers and teachers. However, they may, drawing on intuition and deduction from user accounts, be "perceived directly", and perception of actions can precede internal mental ordering. Perceptions of affordances can, and do, become habitual. Affordances arise because of real physical and symbolic properties of objects. Affordances provide both opportunities and constraints. Affordances are always relative to something and, in the context of ICT, relative to desirable goals or strategies for teaching and learning. Affordances are often sequential and nested in time.
>
> (Hammond 2009, p12)

The analysis of relatively static, immutable environments (and tools) discussed in the literature on affordances does not necessarily extend to the dynamic and extensible nature of the computer, unless we only concern ourselves with the surface physical properties. The computer not only hides its functions behind visual interface hierarchies, thus making perception of affordance challenging, but is almost infinitely extensible and customisable through programming and preferences, thus chimeric. Nevertheless, the concept of affordance serve to remind us of the need

to understand the complexity of mental models that learners (and teachers) must develop to be effective in learning with computers and how obscure and diverse the functions available can be.

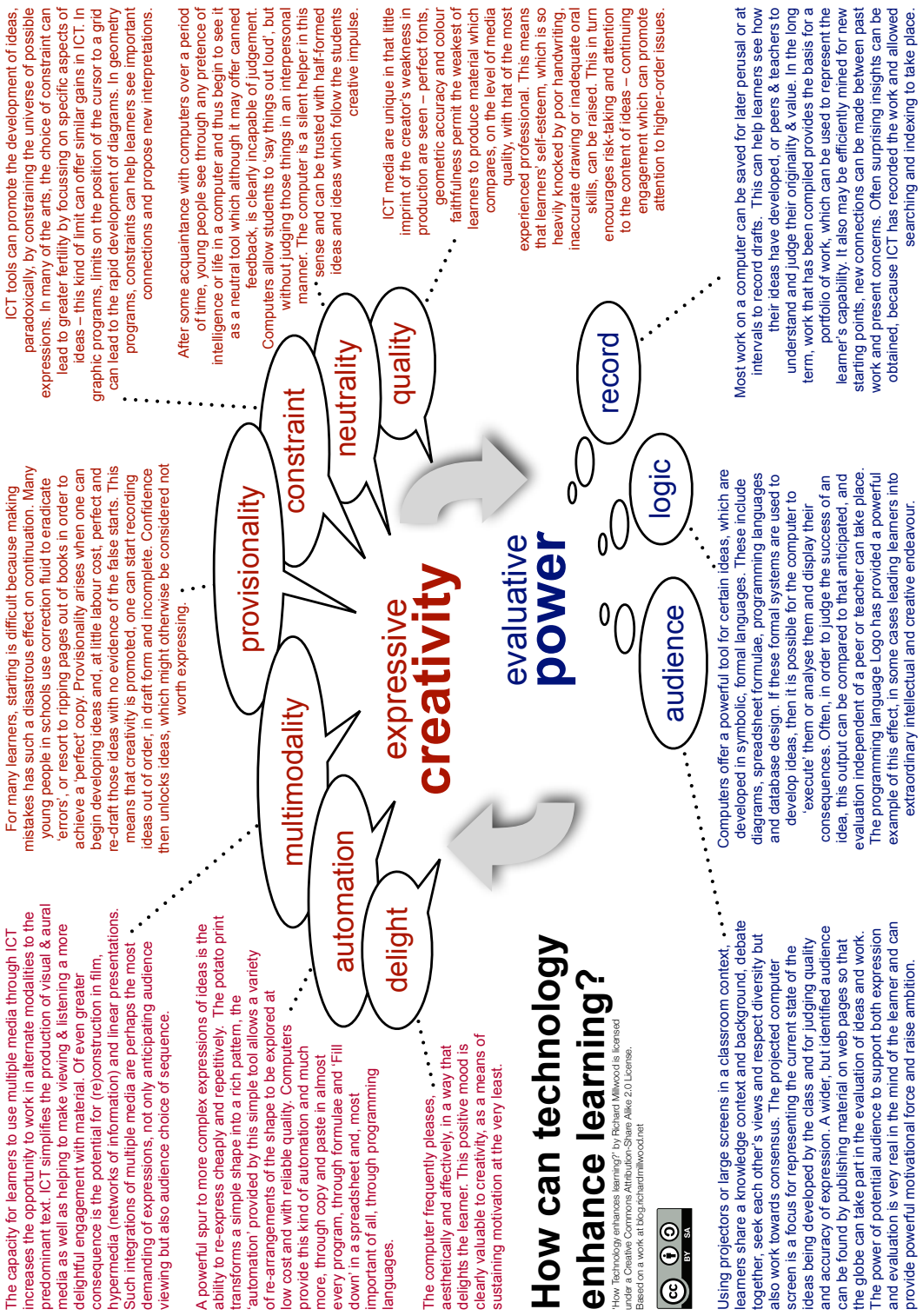


Figure 10: How can technology enhance learning? (Millwood 2012)

4.7 [A3] The Learner at the Centre

This conceptual model captures a learner-centred analysis of questions that might be asked in order to make decisions at all stages of a cycle of learning within an educational context.

Focussing on the learner's perspective meant imagining a complete set of essential questions that they need answers to in order to progress in education. Normally these questions are not asked, the answers are simply supplied by the educational organisation. But by taking this perspective, gaps in the designs I developed for educational organisations could be identified and closed in the development process. For example, a design may make provision for formative assessment (7 Assessment, in the analysis) but forget that it may also be important have some means to gain an award (8 Recognition) through summative assessment.

> Few real learners will articulate such concerns in the form of questions, partly because we usually do not ask them to participate in such issues, but by posing these questions as ‘constants’ we may test future proposals more effectively than starting from the status quo of a current or historical solution. In this diagram, the learner is imagined to be concerned with eight questions, relating to eight areas that an innovator should consider if they wish to make an impact on learning with an invention in technology or practice.
>
> But the issues at the bottom of the diagram – responsibilities and rights – are at the heart of the modern dynamic that education and technology present. Learners’ entitlement to access knowledge was at the heart of the development of the National Curriculum, but we must add to that the entitlement to opportunities for access, creativity and communication and the responsibilities that a free and open education brings.
>
> (Millwood 2009b, 20)

The lists of issues related to each question will form part of a future research & development to elaborate this analysis more fully.

Figure 11: The Learner at the Centre

4.8 Validity and Reliability

This section has described a thesis that has developed through practice, and there is a need to explain the validity of this thesis and discuss its reliability.

In qualitative research, much of the debate about validity and reliability depends on triangulation (Golafshani 2003). The analyses presented as this thesis have been exposed to considerable 'stress testing' in numerous projects, many on the large scale and the national stage with many collaborators. In addition they have been shared with colleagues, students and professional contacts in practice, teaching and professional dialogue. Some have been peer-reviewed in the context of projects deliverables. Thus their external validity derives from this exposure and the critique that has been offered by others leading to improvements and good evidence of generalisability.

In each analysis there is more to be developed in detail and more empirical evidence to be found to make them more rigorous, but there is enough cohesion and precision to make the task of inspiring design proposals and making design decisions possible and indeed effective. In this way I would argue that the thesis has strength in internal validity.

In the sense of truthfulness regarding my contribution, validity has been demonstrated by the triangulation of colleagues agreement, despite concerns about the crudity of percentage measures.

As for reliability, there is doubt about its relevance in qualitative research that is descriptive in nature, such as this dissertation reports, but it can be argued that reliability derives from validity (Golafshani 2003). This thesis suffers from being my point of view and analysis, and the potential is there for bias. Some of this is offset by the nature of my practice as collaboration (others have had a hand in the development of the ideas) and other aspects can be triangulated through the evidence offered for each portfolio item. Another indicator of reliability is that the thesis is couched in terms that do not depend on particular educational contexts or developments in technology and have stood the test of time in my career.

4.9 Next?

This section identifies next steps in my practice and future directions for research and development.

My new post at the time of writing (November 2013) is as Course Director at Trinity College Dublin for their Masters in Technology and Learning. The course provides me with the best opportunity to make use of my background and, in designing and preparing learning experiences for the students, to improve my theoretical analyses in three ways: flesh out the detail; enhance coherence; and provide interpretation with respect to design decisions that educational developers must make.

At the same time, I hope to seek PhD supervision rôles that encourage development of these analyses including correction and extension. This may include seeking empirical evidence to strengthen what I claim is a valid designer's tool-set to have greater scientific reliability.

The other major direction forward is to develop the potential of the National Archive of Educational Computing to become a trusted and rich research resource. This includes continuing to design new software, but based on some of the ideas developed and forgotten over the last four decades which are stored in the archive. The comparison of a modern design with its updated pedagogical thinking against the original material will in itself clarify trends in education, but also provide a basis for critiquing both past and present. This strategy has the added value of providing a relevance, currency and forward direction to the archive which is easy to dismiss as simply backward looking.

In order to achieve this objective, I will need to make new alliances with disciplines I have so far not touched upon and learn about historical interpretation, artefact curation & preservation, cataloguing and knowledge engineering - a challenge I relish!

5 Conclusion

This dissertation presents a thesis formed of three design analyses [A1, A2, A3] and discussion and analysis of the 11 selected items from my portfolio which provide an empirical basis for the theis. These, supported by methodology and a theoretical & conceptual framework, make a claim for the award of PhD. The key to this is the practice itself, which I argue has been internationally significant in originality, impact and importance.

Starting with the development of a single piece of educational software, Snooker, created at the time the genre was established, I have grown in ambition to ultimately design educational infrastructure based on significant projects such as Ultraversity, which at its first graduation in 2006 awarded a BA to around 150 students with almost half with first-class honours.

My work has been guided by the theoretical analyses I have presented which have been used in practice to steer design decisions. These form an original contribution to knowledge that will become the basis of further research & development to refine their validity and support their reliability. The portfolio selection made could have been larger, but a pragmatic decision to limit the choice for both handling and for coherence has been made.

My contribution has mostly been in collaboration with others, but in total, I argue there is enough evidence of my individual input, often in the form of critical advice and mentoring to colleagues as well as personal creative innovation.

Finally, I have developed this thesis extensively by using a web site and content management system to source, develop, organise, design and present my argument and hope that the model I have explored, described in the section Methodology for this dissertation will act as useful basis for others to follow in my footsteps.

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Appendix 1 - Portfolio of 11 selected items

The selected items in the portfolio on which the thesis is based.

[P1] Researcher in the Computers in the Curriculum Project at Chelsea College London

Sep 01, 1980 to Aug 31, 1990

I was employed by Bob Lewis, Director in 1980, at first to translate paper tape software simulations to cassette and floppy disk. I continued under Margaret Cox's direction, developing over ten years as a team adviser, lecturer, educational researcher and author.

> **Aim**: To establish design leadership for teams of programmers developing computer assisted learning for secondary age students.

I was the first employee at the Computers in the Curriculum project to be hired as a programmer, their earlier programs having been developed by teachers, lecturers and helpers.

I took this post after applying for two others in the field for which I was shortlisted, firstly for the ITMA Research Fellow, and secondly to have been research asssistant at the Polytechnic of the South Bank working with Morfydd Edwards. I didn't get the first and declined the second in favour of the job in the Computers in the Curriculum Project, which offered greater scope and prestige as well as a longer contract!

> **Reflection**: The design challenge of taking a finished piece of software and make it work in a quite different interactive graphical environment was a real foundation for understanding the interoperability issues and design questions for educational software.

My first challenge was to acclimatise to the more laid-back HE sector as a researcher after working as a teacher in school. My work was to take programs developed for minicomputers to output onto teletype which were distributed on paper tape, and make them suitable for use on microcomputers with 'glass-teletype' screens. As graphics capabilities became more widely available, we began to develop more interesting and visually clear outputs, often graphs, but increasingly diagrams and visualisations.

> **Reflection**: The design of simulations that invited students to make decisions and evaluate consequences was based on innovative and learner-centred pedagogy.

In 1981, the establishment of the Microelectronics Education Programme (MEP) (Fothergill, 1981) by the government led to a large investment in the development of software by our project. This meant the expansion of our software team and our whole enterprise.

I was attached to several groups of teachers to develop simulations, notably the Economics 14-16 group (based in Stoke-on-Trent) and the History 13-16 group (based in Leeds). My activity was to develop software that responded to the teachers' ideas and specifications and that was suitable for the range of microcomputers becoming available to schools. I became responsible for the 'Subroutine Library' designed to offer an interoperable framework for development amongst a team of a dozen programmers.

> **Reflection**: Teaching programming to adults in the context of their development as computer studies teachers caused me to consider the pedagogy of computing afresh with considerably more articulate and educationally aware students. Together with discussions with colleagues I developed a lifelong interest in the role of computing as a subject for learners. My widening role as a higher education lecturer at Masters level gave a broader view of the educational computing scene beyond the merely technical and towards a social, cultural and systemic understanding. As a lecturer in Mathematics Education, I was regularly visiting schools and engage in debate with practitioners so that I could keep my feet on the ground.

In the middle of this decade I was invited to teach programming as part of a new Diploma course to re-train a range of subject specialist teachers to take responsibility for Computer Studies. In turn this led to greater involvement in the Post Graduate Certificate of Education (PGCE) programmes, and finally I took on the rôle of Mathematics Education lecturer for part of my time and also designed and delivered a Masters module on the Social Context of Educational Computing.

> **Reflection**: The role of MESU fellow made me take a nationwide perspective across private and public developments in educational computing.

Meanwhile my development work evolved into a Micro-electronics Education Support Unit (MESU) fellowship in Software Tools, for which I was expected to investigate and evaluate tools for authoring educational software. As part of this work I pioneered the use of the Compulink Information Exchange (CIX) online community to connect educational software developers around the country and to continue professional discussion beyond our face-to-face meetings.

> **Reflection**: Team leadership for development of interactive multimedia gave me real responsibility for design and development guidelines for others in our large nationwide team, giving me a first taste of leadership in educational computing.

Towards the end of this period, I became involved in developing using HyperCard and with colleagues wrote books to guide others on how to design in this environment. We also began to create interactive multimedia and CD-ROM software.

> **Contribution**: I designed and developed many educational programs, guidance documents, course materials and developed analytical models for evaluation of user-interfaces. I exercised nationwide team leadership and national leadership in educational software interoperability. My part: 100%
>
> **Originality, impact and importance**: The Computers in the Curriculum project, first established in 1973, was one of only a very few world-leading curriculum development projects in its time to create brand new computer assisted learning materials based on a 'revelatory' approach using simulations (Millwood, 1987, 8). There were very few predecessors in the schools sector. It was funded for the first half of the eighties by the UK government funded Micro-electronics Education Programme, absorbing a large proportion of its budget. The materials were widely published internationally through Longman, BBC and others. The work covered a wide range of subjects in the secondary curriculum. (Watson, 1987)

Evidence: The project impact on the UK and internationally is evidenced in the Computers in the Curriculum Newsletter No. 6 (Donoghue 1984) Which shows the breadth of engagement, size of the enterprise and the impact being made at conferences worldwide.

[P2] London Mental Models Group

Sep 01, 1986 to Aug 31, 1990

This multidisciplinary research group was led by the late Joan Bliss of King's College London and involved staff in science, mathematics and history education, but also in language, cognitive psychology, educational computing, expert systems and artificial intelligence.

> **Aim**: To discover new perspectives on the mental models of learners with regard to their use of technology as a tool for developing such models.
>
> **Reflection**: The group provided me with a regular and powerful discourse to engage with in relation to the role of computers in learning and in particular analysing the nature of modelling and simulation software and its potential for learning.
>
> **Contribution**: I participated and contributed ideas to seminars considering models of learning with technology. My part: 5% (Project led by the late Professor Joan Bliss)
>
> **Orginality, impact and importance**: The work to integrate an educational approach to technology, learning, artificial intelligence and mental models was unique, recognised by an Economics and Social Research Council grant for the 'Tools for exploratory learning' project (Bliss & Ogborn 1989) and peer-reviewed publications. It had impact on the design of new modelling software and importance in raising the level of debate at an early stage in the maturation of technology in education amongst the educational research community in London.
>
> **Evidence**: Joan Bliss' obituary (Ogborn 2011) contains testimony to the significance of this group.

The group's members were from King's College London, the Institute of Education, Imperial College London and Kingston Polytechnic and met monthly.

The common ground was Education, with specific focus on modelling cognition to inform more generally issues of learning and teaching in an information technology setting.

[P3] Procedure Library

Jan 01, 1987

This was a library of procedures in Pascal and BBC Basic written on a range of computers to provide an interoperable set of functions for educational software. It was the successor to the Subroutine Library. The package was complemented by a technical guide and a design guide.

> **Aim**: To improve standards of interoperability in the design of educational computer programmes.
>
> **Reflection**: This work followed earlier attempts in the Computers in the Curriculum project to standardise software development and user interface in order to provide users with confidence, but this was not agreed by all. Others were keen to innovate and felt that standards would inhibit innovation. The needs of users won out in the end as the industry more widely created graphical user interfaces with consistent controls and software developers reaped the benefits, particularly pioneered in the Apple Macintosh operating system. I learnt that a learner-centred approach helped design decisions in this contested area of development.
>
> **Contribution**: I designed the set of procedures and functions, wrote the BBC BASIC and Pascal code and technical guide and co-authored the design guide which included the creation of the diagram and analytical explanations. My part: 50% (with David Riley)

In the late eighties, BASIC as a programming language was beginning to show its age. It had originally been chosen for its ubiquity on small computers that schools and colleges could afford, but towards the end of the decade, computing power had increased to the point were a much wider range of powerful programming languages were readily available.

This situation inspired the development of the Procedure Library, focussing on BBC BASIC's extended capabilities and the language Pascal on other systems. It was intended to continue the principle of interoperable development established in the earlier Subroutine Library. As well as the program code for the Procedure Library, two guides were written in October 1988 'The Procedure Library Technical Guide' and 'The Procedure Library Design Guide'.

I worked on the latter with David Riley to produce the diagram Analysis of a Single Interaction (Millwood and Riley 1988) after reading Donald Norman's work (Norman 1983b) breaking down the steps of interaction with a user interface which we expanded on to analyse the user's perspective when engaging with educational software.

> **Originality, impact and importance**: The design, code and analysis were new, based on lessons learnt over seven years of using a BASIC subroutine library and the best of graphics routine library literature (Newman and Sproull 1989). The impact and importance was on the development and design of educational software by the Computers in the Curriculum team.
>
> **Evidence**: My leadership is documented in the Computers in the Curriculum project publications, including Newsletter 6 Computers in the Curriculum Newsletter No. 6 (Donoghue 1984).

[P4] Senior Lecturer in Ultralab at Anglia Polytechnic University

Sep 01, 1990 to Aug 31, 1998

I was employed by Stephen Heppell to build Ultralab as a developer, technical expert and mentor in the design of interactive multimedia software. I also had a role as lecturer in ICT in Education.

> **Aim**: To develop a collaborative team approach to the design & development of new technology in learning.

I was employed primarily to carry out project duties to develop multimedia CD-ROM materials in the first instance, and over the next eight years the work developed into designing and developing software for primary children, for language learners and increasingly, young people developing multimedia for themselves.

> **Reflection**: The real value of this job for my development was an increasing level of responsibility and a powerful combination of design, development, team leadership and teaching at a high level.

In addition to my software development and project duties, I was employed in the School of Education to teach Primary and Secondary B.Ed. student teachers about computers in education and some part-time Diploma work which grew into a set of Masters modules developed and delivered with Stephen Heppell in the evenings.

As our project scope and team expanded, I found myself more and more in a mentoring / leadership role with both internal colleagues and with external collaborators, and the internet and online community became central to our work.

> **Contribution**: I was a designer, developer and technical producer of many projects, a lecturer in ICT in Education and a designer and developer of a Masters level course. My part: 25% (with Stephen Heppell and others)

> **Originality, impact and importance**: The Ultralab team was distinctive in its structure, ethos and practice, developed on values and principles of inclusion and participation. Its ethos was to directly change the world of education with its action-research innovations and thought leadership. Its work influenced national policy in the UK through Ultralab director Stephen Heppell's leadership in the Stevenson inquiry and beyond through membership of governmental advisory bodies and a regular diet of high-level keynote presentations at conferences.

> **Evidence**: The Stevenson Report (1997) and my membership of the UK government's Learning Software Task Force.

[P5] Translating software: what it means and what it costs for small cultures and large cultures

Jan 01, 1994

This paper discussing the case for making software translateable was written with Dai Griffiths, Stephen Heppell and Greta Mladenova and was selected for publication in the journal Computers & Education after presentation at the CAL '93 conference

> **Aim**: To clarify the importance of designing in opportunity for self-localisation to educational software to allow regional and international appropriation.

Abstract

In this paper the authors report as a case study their experience of adapting a set of software for other languages and cultures, drawing attention to the potential pitfalls and sharing what was learnt. This experience was based on a project to translate the 'Work Rooms' software for young learners into Bulgarian and Catalan. It is also hoped to broaden the debate on CAL, stimulating consideration of multicultural and international issues.

While the questions raised by this particular adaptation of software are relevant to all those working with CAL, they have particular importance for software authors, publishers, and teachers of linguistic minorities.

Reflection: The discussion and research arising from the developments we made to create programs in the 'Work Rooms' suite as user-translateable software, had a far-reaching influence on my awareness of the importance of seeing the world from the position of the learner within the culture they inhabit and the language they use, not simply what their interests or processes in learning might be. It made clear how profound the concept of learner-centredness needed to be.Contribution: I helped design the software methodology for translation and the implementation of it in the 'Work Rooms' software as well as co-authoring the paper.My part: 20% (with Dai Griffiths, Stephen Heppell, Sam Deane and Greta Mladenova)Originality, impact and importance: The practice and paper was novel in education at that time and the conceptual thinking was only just making impact in the software operating systems world. Its importance is seen in the way modern software is now developed and content management systems such as Plone have been developed to manage translation as a matter of course.

[P6] Étui

Sep 01, 1998 to Jul 28, 2000

This EU-funded project developed an educational toy to support children's learning as part of the Experimental Schools section of the i3 network (Intelligent Information Interfaces). The device stimulated meta-level learning awareness, problem solving, creativity and collaboration through the activities it was designed to enable.

> **Aim**: To research & develop a toy for use by early learners to encourage learning about learning.Reflection: In the éTui project, I proposed the ideas of meta-level learning that the toy would foster based on more general ideas of identity, reflective activity and exploratory learning.Reflection: The guided experiments I carried out in the primary classroom helped me understand the profound effect of participant research and the depth of thinking that an exploration of the unknown can promote.
>
> **Contribution**: I acted as co-developer of the project's ideas about meta-level learning, mentor to the project leader and other personnel, researcher in classrooms and disseminator of the progress and outcomes. My part: 20% (with Andy Simpson, Dai Griffiths, Stephen Heppell and Kris Popat)
>
> **Originality, impact and importance:** The project was unique for its design of a mysterious toy which did not represent existing creatures in order stimulate wonder, inquiry and imagination. As part of the i3 research network, it was shared widely to the European research community and generated much debate about early years learning with technology.
>
> **Evidence**: Étui was disseminated at the conferences in 2000 and 2001 of the EU-funded Future and Emerging Technologies i3 network and at an invited workshop titled Children as Participant Designers at FutureLab's inaugural conference Contagious Creativity in June 2002.

This project summary is taken from the original bid:

Project Summary

Objectives

The éTui will be a prototype electronic device for young learners. The learning activities which the device should stimulate are: problem solving, collaboration, creativity and meta level learning awareness. The design objectives of the device to support these are: programming through direct manipulation and iconic program representation; real-time synchronisation between one éTui and another; multi-sensory capacity (perhaps including motion, sound and vision) and response based artificial learning.

Results

The project will result in the following:

- A prototype electronic learning toy - the éTui.
- Information from the design stages and field trials.
- A set of specifications linked to learning outcomes.

- Software resources designed for the project including operational, visual, programming and interactive elements.
- A specification for further development based on an evaluation of the project.

Approach

The project will include: four testing stages, software development, hardware development and dissemination. The testing stages will have two distinct research populations: the four main field research sites and an online community of research reference sites. The four stages of testing will be for the conceptual visual designs, the conceptual physical designs, the conceptual software design and the final prototype. Ultralab will coordinate the project, create the research infrastructure and undertake work in conceptual software design and conceptual hardware design, the last two in conjunction with Apple. Conceptual visual and physical designs will be managed by Pompeu Fabra.

Outcomes and Impact

We expect the éTui to engender a new philosophy for creating toys for young learners, one which will make the process of fully exploring such a device intuitive and flexible. The information gathered from the field testing stages should create further debate in this area and also inform design goals for further prototypes. This information linked with the specifications and the software resource should make a firm foundation for further work in iteratively testing and designing the éTui.

Dissemination

Information about the project and project results will be communicated through a variety of channels. These channels will include the world wide web, popular television or printed media and publication. There will be a site dedicated to the project on the world wide web which will describe results and show the current stage of the project. Specific outcomes may be prepared for television broadcast and/or publication.

[P7] Input CBBC

Oct 01, 2002 to Feb 28, 2003

A collaboration between Children's BBC Television and Ultralab to explore the future of kids TV. Computers and digital video cameras were placed in schools, community and learning centres across the North of England to find out what television could be like if children were to make it themselves.

> **Aim**: To design the support web site to explore the potential for students' creativity with video to be broadcast.
>
> **Reflection**: Although Ultralab had shown that young people were capable of this kind of creativity, we were challenged to demonstrate this when working with other adults and young children from a range of backgrounds and the BBC's senses of propriety, quality, health & safety and risk analysis.
>
> **Contribution**: I took the role of co-leader at Ultralab developing the key values, participant action research approach and philosophy, working with the CBBC Future TV section at the BBC. I took on the visual and information design challenge of presenting help, templates and guidance in a child friendly web-site whilst maintaining a connection to the CBBC's visual style. My part: 25% (with Matthew Eaves and others)
>
> **Originality, impact and importance**: The project was quite new for a national broadcaster to take a serious view of children's digital creativity. Its impact was on the BBC itself in informing its future policies and confirming the research outcomes from earlier Ultralab projects.
>
> **Evidence**: The final report (Derrick 2003) was edited by Cathy Derrick, a senior director within the BBC and was circulated to her colleagues to inform them in making sense of user-generated content by young children.

From the final report of the project:

SUMMARY

Input CBBC was a research pilot project which ran from October 2002 to February 2003, developed by CBBC, in collaboration with Ultralab, a research centre of Anglia Polytechnic University. It encouraged a group of children who'd never made a film before to produce their own output. It attempted to give children control at every stage of the process - from idea through editing to screen. It aimed to investigate the best ways to encourage such output, thinking ahead to a future where these methods could potentially be used on projects with bigger scale. Further pilots could also test the viability of children constructing whole magazines for themselves on broadband, with some content produced by them, other content being professional items.

It was known from the start that Input CBBC would be a tall order - the aim was to test its ideas harshly - to see if any child, with no special ability or ambition, could succeed at filmmaking with little guidance.

Forty children in Sheffield and twenty four in Hull, aged ten to fourteen, took part, working in groups of around four. The pilot was conducted “at arm’s length”, through established institutions, such as schools, community groups and City Learning Centres, with each group of children supervised by an approved responsible adult. The adult’s role was to organise film-making sessions, keep children safe, provide limited technological help if the children got stuck - but not to interfere in the creative process.

The children were introduced to digital cameras and to the editing package called iMovie by CBBC and Ultralab, then encouraged to learn through play and experimentation. They were made aware of important aspects about making a film, such as safety, copyright and editorial considerations. Amongst other methods of support available, Ultralab developed a prototype website, which also acted as a base for information and contact.

Final Conclusions

So, to conclude

- this was an experiment - and it was tested really harshly - but still came up with results. It has proved that when children get their hands on equipment they are clearly producing media that is of value to them, for the first time.
- the children and adults were co-researchers, keeping logbooks, doing interviews, being filmed. The research and their films are proving fascinating.
- Input CBBC encouraged some more voices and empowered a group of children to make films
- the other stated aims, of investigating and learning from how best to encourage this material, were met.
- the project established ways of handling health and safety issues and rights management for user-generated CBBC projects at arms length

Input CBBC helped some children see television with new eyes:

> First child: “We know how hard it is to make the films and stuff.”
>
> Second child: “You just watch TV and like you don’t like see all the work that has been put into it.”
>
> First child (of a different group): “I take a bit of sympathy with people who have the worst parts.”
>
> Second child: “Yeh like soaps that have to make four half hour ones every week and it took us three months to do one minute, but they probably have millions of people.”

Input CBBC has proved children can be creators of content - and these are not children with special abilities or a burning ambition to make films - and they come from many different communities.

- but it is not easy for children to produce films, because of the factors described earlier in this report
- The jury is still out about the true extent that children may in the future be able to contribute en masse to programmes, much as they send letters and pictures in now.

- CBBC, as the country's foremost broadcaster to and for children, remains the best place to give children a voice on television. It is a stated aim that "your input is our output" and this project has fed that aim.

Finally, it is not just broadcasters who have learnt from this experience. Input CBBC has proved that filmmaking is a journey of growing self-discovery, self-expression, self-discovery and confidence building for the children concerned:

> "Working as a team gets you a lot further than working by yourself."
>
> "I've learnt how to work as a group. I've never done that before. I've always wanted to be on my own which is my fault. I've learnt to be as a group, to be a good team-member."
>
> "I've learnt not to get frustrated when I want to use the computer and someone else is using it."
>
> "I can be hard to work with sometimes, very stubborn."
>
> "I've learnt not to get in a moody as such but to join in with the fun."
>
> "I kinda liked doing everything but I don't think I would have been able to do it on my own - we needed each other."

[P8] QCA - An Investigation Into Pupils' Creativity Across The Curriculum

Nov 01, 2002 to Mar 31, 2003

I contributed to this UK Qualifications and Curriculum Authority consultation as a member of a panel contracted to synthesise clearer ideas about ICT and creativity towards the end of a wider effort to consider creativity across the curriculum from 2000-2003

> **Aim**: To clarify criteria that explain why technology enhances creativity in learning.
>
> **Reflection**: The summary table at the end of this article was developed by the QCA project to characterise creativity and the rôle of ICT. The development of all of these ideas, in the company of several colleagues who I highly rated for their thinking, gave me confidence in the usefulness of my analysis of the potential contribution of ICT, as my work provided a major part of the 'Features of ICT' column in the table.
>
> **Contribution**: I joined meetings to discuss and then write a contribution to the committee's report, the 'Features of ICT' section outlining how technology can enhance creativity. This contribution later became the basis for my analysis How technology can enhance learning [A2]. My part: 20%
>
> **Originality, impact and importance**: This was a synthesis of my original thinking and other sources including my experience as a designer in discussion with many others. This was newly articulated in print by me for this consultation and adopted by this national advisory body as part of a taxonomy for advice on future curriculum thinking nationally.
>
> **Evidence**: The brief, my report and the taxonomy are included in the portfolio:

This is the original brief for the work:

Brief

An Investigation Into Pupils' Creativity Across The Curriculum 2000 – 2003

Contractor: Richard Millwood (Ultralab) - Budget Code: Fee: £2000 - Deadline: 24 January 2003

Context

In March 2003 QCA will be providing advice to Creativity Advisory Group (CAG), and then ultimately Ministers, on the potential of ICT for promoting creativity across the National Curriculum. We want your work to inform that advice.

Purpose

To clarify how and why pupils' creativity is promoted through their use of ICT to develop ideas and judge value and originality.

Requirements

Write a paper which:

- Explains how and why this use of ICT promotes creativity, making reference to:
- the effect of the relevant features of ICT;
- the effect on pupils' creative thinking and behaviour;
- the types of ICT applications used;
- evidence of the effects of this use of ICT in practice.
- Highlights the potential for this use of ICT to promote pupils' creativity.
- Makes recommendations and raises key issues.

Critical Success factors

The paper:

- is written in plain English.
- covers the requirements above.
- can be used to inform advice to the CAG and Ministers on how and why ICT promotes creativity.
- is received by the deadline date.

Deadline

Send back the completed paper back to QCA by Monday the 24th of January.

Project Management

Seb Ross, QCA Subject Manager, will oversee the work of the contractor. Please also send the paper via e-mail to rosss@qca.org.uk.

Copyright

QCA owns all relevant data and material produced under this project. A note confirming that the contractor understands these terms and agrees to comply with them will be included in the contract.

My contribution:

An Investigation Into Pupils' Creativity Across The Curriculum 2000 – 2003

Contractor: Richard Millwood (Ultralab)

DRAFT 2 February 14th 2003

Introduction

It is commonly held that the basis for an innovative and financially healthy nation is the creativity of its adult population in the workplace.

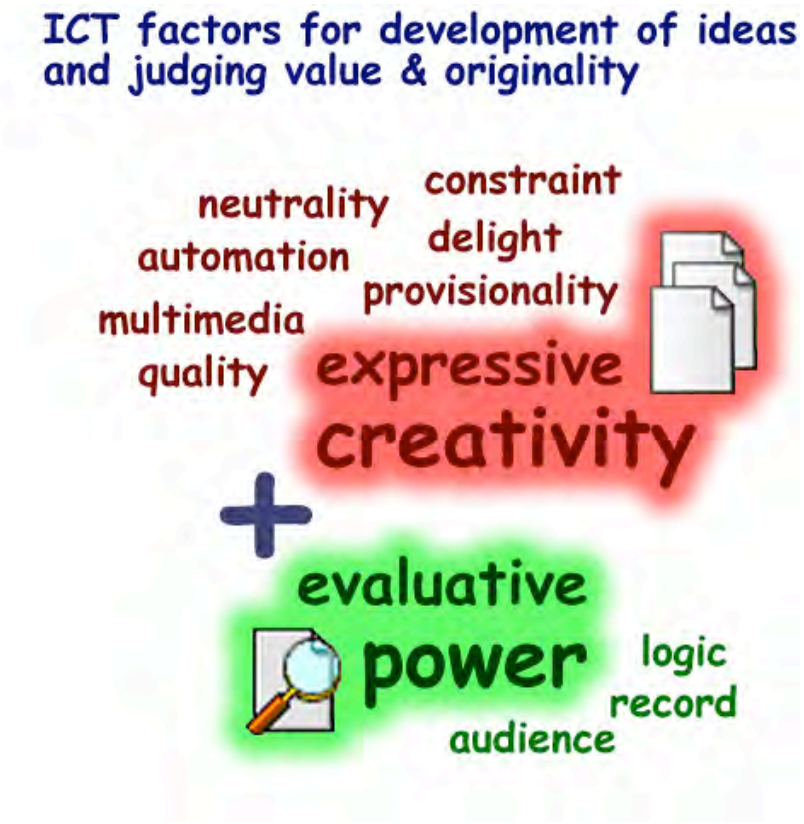
> "Our success depends upon mobilising even more effectively the imagination, creativity, skills and talents of all our people. And it depends on using that knowledge and understanding to build economic strength and social harmony,"
>
> Charles Clarke, UK Secretary of State for Education

in the government's white paper 'The Future of Higher Education' January 2003

I argue that creativity is more important than that, and that it underpins all learning in the development of ideas and concepts and furthermore fulfilment in people's lives. As a natural part of everyday activity learners are creative in thought (as they listen, read or watch), natural expression (as they speak, play, perform or make) and more formal recorded expressions (as they write, diagram, prove or program a computer). Information & Communications Technology (ICT) can promote such expressive creativity in a number of ways to be described in this paper.

But expressive creativity has to be matched with evaluative power in order to develop ideas and to judge them for value and originality. ICT also has role to play in enhancing evaluative power. Normally expressive creativity and evaluative power will happen in a cycle of improvement which ICT can enhance and maintain.

To summarise these concepts, the following diagram shows the factors in ICT which might enhance creativity both in expression and evaluation, and which are expanded and developed in this document:



Creativity in the wider context of classroom, school, community, nation or globe demands increasingly higher levels of originality as measured against these wider contexts and the contributions of increasing numbers.

Creativity at each of these levels of society, from individual to global is natural and instinctive, but is inhibited or enhanced by a number of interacting factors, some of which relate to competition and originality (winning or being unique), others to interpersonal and emotional relationships (valuation of oneself in relation to others) and yet more to skills and competence (ability to articulate creativity). Some of these factors are influenced by ICT, some are reduced in their effect as inhibitors and others enhanced by new opportunities.

It's important to note that ICT cannot act in this way without the complicity of teachers – they are also creative, but need that to be recognised. ICT is often introduced as a support mechanism for the delivery of knowledge, but in this analysis it has to be the tool for developing pupil's knowledge. Similarly teachers should be encouraged to see this perspective, of a tool culture rather than information culture. Thus teachers will not inhibit such use and indeed can join in the debate about the tool of ICT and how it is best used.

How ICT enhances expressive creativity

Neutrality

In a typical learning environment, students often have a stereotypical interpersonal relationship with those around them including peers and teachers. [Hargreaves 1975] This relationship often includes a judgemental factor, which both the student and the peer or teacher feel and which drives a particular negative behaviour: that of avoiding risks with intellectual ideas. This judgemental factor acts to prevent free expression, either because the student fears approbation or because they wish to please others, particularly the teacher, by seeking their answer already known to them but unknown to the student. This in turn inhibits development of new ideas – good teachers (and friends) know how to turn this judgemental factor off explicitly when appropriate.

With ICT equipment, as with other tools and vehicles, there is an imaginary interpersonal relationship (consider the way in which ships are often called 'she' and imagined to have a life of their own). After some acquaintance with computers over a period of time, young people see through any pretence of intelligence or life in a computer and thus begin to see it as a neutral tool which although it may offer canned feedback, is clearly incapable of judgement. Computers allow students to 'say things out loud', but without judging those things in an interpersonal manner. The computer is a silent helper in this sense and can be trusted with half-formed ideas and ideas which follow the students creative impulse.

Automation

A powerful spur to more complex expressions of ideas is the ability to re-express cheaply and repetitively. The potato print transforms a simple shape into a rich pattern, the 'automation' provided by this simple tool allows a variety of re-arrangements of the shape to be explored at low cost and with reliable quality.

Computers provide this kind of automation and much more, through copy and paste in almost every program, through formulae and ‘Fill down’ in a spreadsheet and, most important of all, through programming languages.

Arguably, programming has lead to the current information age, since all technologies related to ICT rely on computer programs to automate functions to a level where qualitative changes in education, the workplace and society as a whole have taken place and are still developing. This explosion in creativity ought to be more widely available to all learners in educational contexts, but suffers from a disregard for tools which is an endemic problem in our society [Owers 2001].

Multimedia

The capacity for learners to use multiple media through ICT increases the opportunity to work in alternate modalities to the predominant reading and writing. ICT simplifies the production of visual and aural media as well as making viewing and listening a more delightful engagement with material. Of even greater consequence is the potential for reconstruction in film, hypermedia (the establishment of networks of knowledge) and linear presentations. These are integrations of multiple media and are perhaps the most demanding of communications, not only anticipating audience viewing but also audience choice of sequence.

Quality

ICT media are unique in that little imprint of the creator’s weakness in production are seen – perfect fonts, geometric accuracy and colour faithfulness permit the weakest of learners to produce material which compares, on the level of media quality, with that of the most experienced professional. This means that learners’ self-esteem, which is so heavily knocked by poor handwriting, inaccurate drawing or inadequate oral skills, can be raised. This in turn encourages risk-taking and attention to the content of ideas – continuing engagement which can lead to judgements about higher-order issues on a level playing field.

Constraint

ICT tools can promote the development of ideas, paradoxically, by constraining the universe of possible expressions. In many of the arts, the choice of constraint can lead to greater fertility by focussing on specific aspects of ideas – this kind of limit can offer similar gains in ICT. In graphic programs, limits on the position of the cursor to a grid can lead to the rapid development of diagrams. In geometry programs in Maths, constraints can help learners see important connections and propose new interpretations of figures.

Delight

The computer frequently pleases, aesthetically and affectively, in a way that delights the learner. This positive mood is clearly valuable to creativity, as a means of sustaining motivation at the very least.

Provisionality

In order to embark on any piece of work of substance, a start has to be made – for many learners, making this start is difficult because making mistakes has such a disastrous effect on continuation. Many young people in schools use correction fluid to eradicate 'errors' as they perceive them, or resort to ripping pages out of books in order to achieve a 'perfect' copy. Provisionality is that certain knowledge that with a computer, one can begin developing ideas and, at little labour cost, perfect and re-draft those ideas with no evidence of the process. This means that for creativity, one can start recording ideas out of order, in draft form and incomplete. For many, this knowledge unlocks their ideas, which would otherwise not be worth expressing.

How ICT enhances evaluative power

Logic

Computers offer a powerful tool for certain ideas, which are developed in symbolic, formal languages. These include spreadsheet formulae, programming languages and database design. If these formal systems are used to develop ideas, then it is possible for the computer to 'execute' them and display their consequences. Often, in order to judge the success of an idea, this output can be compared to that anticipated and evaluation independent of a peer or teacher can take place. The programming language Logo has provided a powerful example of this effect, in some cases leading learners into extraordinary intellectual and creative endeavour. [Papert 1980]

Record

Most work on a computer can be saved for later perusal or saved at intervals to record drafts. In the development of ideas this can help learners see how their ideas have developed, or peers and teachers to understand and judge their value and originality. In the long term, work that has been saved in this way and compiled provides a portfolio of work. This portfolio can be used to represent the learner's capability, but also may be mined for new starting points by that learner in a much more accessible and labour saving way than with a traditional portfolio. New connections can be made between past work and present concerns – often surprising insights can be obtained, because ICT has recorded the work and allowed searching and indexing to take place.

Audience

ICT offers a number of ways to allow communication of ideas to take place, both deliberately and serendipitously. By using presentation tools, learners can show and defend their ideas to audiences in the whole classroom, potentially with access to to the whole body of their work (see Record above).

This kind of ICT use, using projectors or large screens in a classroom context, enhances another kind of creativity which may be teacher-led. This is described as 'interthinking' [Mercer 2002], where learners sharing a knowledge context and background, debate together, seeking each other's views and respecting diversity but also working towards consensus. The projected computer screen is a focus for representing the current state of the ideas being developed by the

class. Some software has been specifically designed to benefit from this shared working knowledge [Millwood & Mladenova 1994], but all software can be used in this mode. It has many of the advantages described above for the individual, but now for the group e.g. quality, multimedia and provisionality. Each of these promote creativity to a far greater degree than a more traditional whiteboard.

By joining online communities through the Internet, a wider, but identified audience can be found for ideas and dialogue with others following the same interest can be informative in order to judge work. Publishing material on web pages permits the globe to take part in the evaluation of ideas and work. This is clearly potential audience not real audience, not all viewers will see or comment on such work. Nevertheless the power of potential audience to support both expression and evaluation is very real in the mind of the learner and can provide powerful motivational force and raise ambition.

Conclusion

The analysis of the development of ideas as a cycle of expressive creativity and evaluative power helps us identify key factors which ICT offers to promote such development, but also the judgement of both value and originality.

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Definition of Creativity	Pupils Creative thinking and Behaviour	Use of ICT	Features of ICT	ICT Applications

• Using imagination • A fashioning Process • Pursuing purpose • Being Original • Judging Value	• Questioning and Challenging • Making connections and Seeing relationships • Envisaging what might be • Playing with Ideas • Representing Ideas • Evaluating the effects of Ideas	• Making Connections • Creating and Making meaning • Publishing • Developing Ideas • Collaborating • Communicating • Creating a learning environment • Assessing	• Provisonality • Interactivity • Capacity • Range • Speed • Accuracy • Quality • Automation • Multi-modality • Neutrality • Social Credibility	• Information resources • Publishing and presenting software • Creative Software Tools • Simulations and Modelling • Programming and Control applications • Datalogging • Databases, Spreadsheets, graph plotters and graphical calculators • Programs that support learning in a specific context.
NACCCE: All our futures: Creativity, Culture and Education, 1999.	Taken from Creativity Pack information sheet 3 (September 2002)	Developed from: Draft Literature Review in Creativity, New Technologies and Learning – A report for Nesta FutureLab (A.M. Loveless October 2002)	Developed from ICT features defined by DFEE 1998 and R Millwood (Ultralab) presentation (October 2002)	Taken from: Key Stage 3 National Strategy – Framework for teaching ICTcapability: Years 7, 8, 9 (DFES 2002)

[P9] Ultraversity Project

Jan 01, 2003 to Dec 31, 2006

Ultraversity was the degree course for those who university did not fit. The design allowed students to focus on their own work, negotiate learning, submit work created as part of their job in the form of assessment 'patches' using the genre and media which suited them, stitch a patchwork of such pieces to make a final submission, celebrate their dissertation through an exhibition and all supported by an online community of inquiry. The design also included the new university infrastructure needed to market, recruit, admit, deliver and manage the course.

Aim: To design and develop a new work-focussed online university experience to suit 'those for whom traditional university did not fit'.

Reflection: Through this project I consolidated my knowledge and developed new ideas for course design, modular frameworks, online community of practice, action inquiry as a pedagogic model and assessment through patchwork media and exhibition. I also helped developed concepts of business model & operational thinking, and as such it was the closest to the design of a new higher education institution that I had engaged in. I consider it to be the most significant project of all my experience, in that it successfully empowered many hundreds of students in meaningful and effective ways, delivering on the promise of technology enhanced learning.

Contribution: Initially, as part of a small team, I developed the documents for validation and designed strategy and materials for recruitment in 2003. I then had oversight of the direction of the Ultraversity Project in my role as Head of Ultralab from 2005 to 2007. I frequently took a practical developmental role, creating and designing resources, infrastructure, marketing, research and team collaboration as well as a refining a theoretical stance to champion the values and philosophy of the project. My part: 20% (with Stephen Heppell, Stephen Powell and many others)

Originality, impact and importance: This project combined unique elements into a completely new fully online undergraduate opportunity. Its impact was felt deeply on the student's lives and on the researchers who made it possible. It influenced a wider academic community that drew inspiration from its success, and continues to be the subject of much interest today as well as a current course at Anglia Ruskin University. Its importance was recognised by newspapers and government ministers at the time. The project helped me enhance the analysis of The Learner at the Centre[A3] in this profoundly learner-centred design.

Evidence: The video and transcripts of the student's own words included in the portfolio evidence the impact on their lives. An account of the project was published in the journal Interactive Learning Environments (Powell , Tindal and Millwood 2008) The Centre for Recording Achievement recognised the contribution and invited me to keynote at their seminar to celebrate 10 years of the patchwork text in which I presented an early version of my analysis of How can technology enhance learning [A2]. A letter from Chris Smith MP outlines the recognition from government. (Smith, 2002).

Ultraversity was a new fully online work- focussed degree employing multiple innovations, with a curriculum and pedagogy created by a small team and further developed and delivered by a 20 strong team for which I had oversight as line-manager to the project director. 144 students graduated in 2006, almost half with first-class honours degrees.

As well as developing a new experience for students, the project developed managerial, operational and team-teaching methods with a geographically distributed group of lecturers using its own online community of practice.

It was the subject of many conference presentations and publications and led to the invitation to create the Inter-Disciplinary Inquiry-Based Learning project at the University of Bolton in 2007.

But a real feel for its impact and unique features may be gained by listening to the students themselves - this video was filmed by Andrew Wood and Robin Cusick at the first major graduation event in November 2006. Together with Greta Mladenova, I transcribed and added text tracks for a transcript and for chapters for navigation:

The complete transcript of the movie is below:

> Eve Thirkle & Sharon Sweeney
>
> Hi Eve, I'm Sharon, at last we get to meet.
>
> Yes I've seen your name many times, but, not met.
>
> I can't believe we're here, it's been, well getting to this stage, a total of three and a half years
>
> Yes, it has been, hasn't it.
>
> That first year doing our first assignment, I never thought I'd be here.
>
> The first Christmas was dreadful, because I was up to all hours thinking 'oooh' why have I chosen to do this?
>
> But it's been fantastic.
>
> Well the opportunities I think it's now actually given me I've not realised until now,
>
> how much it has actually changed things,
>
> how when I look at my old job and things, and different things, then everything is so different.
>
> You're ICT aren't you?
>
> I do ICT and I'm now doing High Level TA
>
> and doing other, I seem to be being pulled to doing other support things this time
>
> it's opened quite a few doors, that I would never have had opened without it

and doing other distance learning, this has been so much more supportive in comparison

The community has been fantastic, hasn't it.

I wouldn't have survived without people like yourself

Oh, thank you!

and staff here, especially in the first year I found it really tough on different things and stuff

but people like yourself kept us going and stuff and it became a team

and although we never met, I think we're actually stronger as a team.

We know each other, but we've never met and it's weird.

And you could mention about fun things, and we did have some fun online with different things and stuff

The celebration on the last night was quite funny as well

That was good wasn't it

We had like a party online.

Well for me it hasn't done so much in job, though, obviously because I'm a parent

But it's made a difference in the way I look at what I do as a parent

and it's always there in the back of my mind, sort of, "ah I'm doing that"

and then I start to think "ah yes", and it's putting that reflection into practice is amazing

and makes quite a difference.

You get a sense of achievement, and when I looked at my first work, and how it was put together

and look in comparison at the end

I know

You realise that you can still learn more, you can take on more roles

I think the way it works gradually, you weren't given more than you could handle at the start

although it seemed like it sometimes

and then to the work that you produce in year three, it's amazing growth

When we went through today and got the gowns and I was getting the gown on

this gentleman Les who put the gown on me, as he was putting it on I was flooding with tears

I knew not to wear make up, because it just meant so much

the idea was, you know, I would love to have had a degree in earlier life, and never got the chance

Same here

and then to do this has just been amazing

and to see the other people and now we're all going round looking at names and different stuff

but I'm finding that its actually making contact, because I've met up with a few other people through other things in education now

Yeah, Well I came straight up the stairs here from reception, saw Glenda and went 'haaa'!

Because it's so great to sort of see the faces, see them in person, it's great

I think sometimes as well, we some of us did put our pictures up, but then we get to here, em

You forget, yeah

I was thinking about my group, that we actually worked in a small group, and I knew their names off by heart

and I've got here today, and I can't think of them, its awful

so I'm sort of looking, but I know the names will trigger

Yeah, yeah once you see them

It's just unbelievable to be here.

And we've got that walk across to get our certificates

I know, I've got, I've had to get new glasses since doing this

because I've actually found my eyesight's sort of being going with age a bit

but I'm not wearing my varifocals today because I'll be tripping up the stairs and different stuff

the actual meeting people and stuff has given me the confidence to now go and do more

and why can't I? and why, you know, it has to be a really good reason why I can't do something now

I found school and things are asking me for things about autism and things, because obviously that's what I've gone into

and the head the other week asked me something about that she didn't actually know

and I could inform her on it, which was brilliant

And when I did my exhibition it was quite interesting when I had some of the like parents coming in

and some who were graduates and stuff

and they'd done a small part about reflection in their degree, and the research a small part

they said "You've done your whole degree through that, how did you manage it?"

I said well, we did!

It's a fantastic tool to actually have

For me, it has had an effect on the school through my research, through the project I did

We have changed some of the things we're doing now

and you think, "I did that!"

I'm going to actually see if I can follow it through a bit more

I don't know what I'm going to do next

but look just to see how that has affected the learning

Next step masters?

Well I think no at first and my husband said no

My husband said no as well

I wondered how I fitted in the time, but everyone says I would find that time again

I think I would, because the rewards I have personally got out of it, it's worth it for me, if nothing else.

It would repay our family if I went on and did work on autism as well, so...

OK, thank you very much.

Manisa Atool Saujani & Carole Bateman

I have been a teaching assistant for about 12 years

Yes, the same as me.

12 years is a long time to be a teaching assistant.

When you see that you do a lot better job than some supply teachers that the school bring in

So, that is what I started off with.

Having said that, now that I've done the degree, I do not want to go into teaching.

Too much hard work, too much paperwork

Yes.

But, I'd say it's had an impact on my workplace.

What school do you go to?

I was a senior teaching asistant in an autistic school for autistic children when I finished my degree.

and as a result of it, I was given an unqualified teachers' post

so I was employed to teach, even though I wasn't a qualified teacher.

And plan activities: take the pupils out and do things.

But now, since I've qualified, I've been accepted onto the graduate teacher programme

and I'm training as a primary school teacher

I work in a primary. With Key Stage 1, 2?

I'm with Key Stage 2 at the moment but after Christmas, I'll be with Key Stage 1.

Prefer Key Stage 1? Teaching primary? Or Key Stage 2?

I like them both actually. Because they are slightly different, aren't they.

But I think I like the older ones more.

Well I did, as part of the degree we did the exhibition, the final exhibition

senior management team saw me as an organiser, somebody who can work ICT

so what they've decided to put me into is Learning Resource Centre at the Primary School.

so I'm now looking after the Library and the learning resources for the school, which is quite a big impact.

I'm sure if I'd just done teaching assistant, I will still be a teaching assistant.

But it's done. Gone that far.

Through the degree then you've been able to show them that you're more than just a teaching assistant,

You've got more skills, than just

and you can go around and say "Now I am a graduate." Got the piece of paper that says I am a graduate,

which was what was stopping me from being a, becoming a teacher in the first place.

The thing is, with becoming a teacher now, it's becoming more challenging

because you now you need literacy, numeracy and science at GCSE level,

which I'm OK with literacy and numeracy, science is not my subject

so, maybe

maybe in the future

in the future, maybe. I might go to take GCSE in Biology or something and then do it

we could do it before now

yes but now they have changed...

but the Age Discrimination Act came from 1st October, so everybody has to have a GCSE in Science now.

Sally Houghton & Helen Smith

OK. Several of my research projects were obviously based at work,

but my last one was about introducing new strategies to reduce barriers to enable in life style interventions groups

and as a result of that, there's lots of changes that were made to the sessions

and I learnt a huge amount about running focus groups

and I think it was good because it involved genuine consultation with the patients and they felt they'd been listened to as well

and the actual changes every single suggestion that they made and intervention was based on what they'd had to say about it.

So then they were able to see, so I think it just restores a bit of faith really in that proper patient-public involvement

yeah, it was really good, though that it was work-based, wasn't it and you could do

because I managed to tie mine into a big project I was doing at work anyway,

so the fact that I could tie it in, meant it was easier for me to do and I could justify doing some of it in work time as well.

But I did a piece about NVQs and quality assurance and trying to tie in the impact that training has on service.

so I mean, it kind, there are some long term effects, I think

around the fact that everybody became a lot more aware about evaluating training

rather than just saying whether it was good or bad or indifferent.

and about actually what the difference is to patients, which I know is something that you tried to tie in as well, wasn't it?

But the NVQ funding has run out, so that's kind of been a bit of a negative side to it but that's outside of control anyway, so you know...

but it was a really good thing to be involved in and my confidence at work is much more increased

because I am dealing with lots of different people now, whereas before it was always training people.

What about you?

As a result of the exhibition that we did in the final year, the team of people I part coordinate with

to give life style intervention advice increased, 'cause people, we needed new members but

that opportunity to exhibit to them gave them an insight more into what the programme's about

so in the end they volunteered to be be involved which is nice because I think they realised that they were doing something worthwhile

It's really hard to get other people involved otherwise, isn't it?

definitely, definitely...

and I think like you say about evaluation it is actually giving me more confidence in evaluating other people's work

in courses that I have been to, I have been confident to be critical really, so hopefully

give them some useful suggestions.

yeah... I mean, a bit of a spin-off for me was because I'd done so much around like reflection and learning styles,

is that I now run all of the team development sessions for our teams,

so that was something quite unexpected but I am really enjoying that and that's what I want to do next.

I want to do something around organisational development

But actually, I recently applied for a job in a college and I played on that the study that we've done into learning styles

and I think that is probably one of the reasons I ended up getting the job,

and they did say, you know: "What's the most memorable thing you've achieved in the last 12 months?"

and it was really nice to say: "Well, I've got a degree."

Not many people able to say that, so

No, no... I mean that's significant when you talk to people

and you say "Oh yeah I did it in three years - and I worked".

Sarah Brown & someone

So, how did you find the degree?

For work it's been really, really useful, especially the third year. The organisation is going through merger

and so I concentrated my final action research on a communication tool for staff

and that's proved really, really popular. We decided to do something that was web based

so that if you are at work or if you are at home you can actually access information about the merger

and especially now we've got all the jobs coming out, I've been able to sit at home,

look at jobs and apply for jobs. So that's been really good.

I think thats been the best bit for me about the degree as well, is that I have been able to use all my work that I was doing at work

and actually sort of go deeper into it than perhaps I would have been able to have done on a general day-to-day basis.

So, and it's helped, you know all the staff I was doing it around the knowledge and skills framework

and I produced a leaflet which they've now found very useful now that they're having to use it,

so that's been good. And I think other people have realised about the degree

and I had lots of congratulations and that, so it's been good.

Yeah, and I think as well, it's the fact that with the sort of action research every time I think of something now,

I was watching Robots, the video, and it was going about find a need, fill a need

and that's how I think now: what's the problem and how can we actually get over it

and I am doing some work with the Department of Health at the moment,

and whereas before I would have just gone: right, OK, let's do it,

I'm going: hang on a minute, is this the right thing to do? what do we need to do? how do we need to accomplish it?

is this the right way of doing it? and asking a lot more questions, which I don't think before I may have actually done

I might have just gone: vro-oom, let's get in there.

Do you think the degree has got you into that work with the Department of Health?

Would you have felt that confident to have done it before?

Probably... I would have worked with them, but I don't think I would have been so, I say, critical

positively critical about about what's been asked of us. I think beforehand, I would have just accepted things,

whereas now I question absolutely everything, which I don't know, it sometimes gets me into a bit of trouble.

but I think, you know that's what it's about, isn't it? So, yeah, on that count it's been really good.

Is it helping you with the merger, 'cause I know with us we are going through major changes

everyone's applying for jobs and that, to suddenly show that you've got a degree is making quite a difference

Yes, it has. Yeah, definitely. Because once I, even at my band you need a degree, so that's fantastic

The sort of the downside is: anything higher, I need a Masters

That's what I have noticed the other day: it said, you know, you had to have a degree, desirable is a Masters or studying towards it.

Exactly, yeah. So really to be at the band I am, I need a BA which I've now got, which is really, really good.

And it's made me think about what I want to do in the future a lot more, because my job isn't about teaching

but there's lots of things I can do with teaching people how to do things.

And I sort of did, for the second year, I did a training guide and I am doing a lot more training just even internally,

and that's the sort of way I think I want to go.

Do you think you will carry on your education now?

Well, I've thought about teaching for two seconds, until I realised it will be little children

But yeah no, I'm seriously thinking about that now, so will see what happens.

And what about you?

It's helped, yes.

Pauline Eustace-Day & someone

How are you feeling, Pauline?

Well, I am more excited than I thought I was going be actually. I was quite calm this morning.

And now I am here, it's lovely, it's absolutely lovely. I feel, we have really done it today coming here, yeah.

Do you know, the people look so different.

I know, I know. I have been looking at everybody's name tags and trying to put the faces to the names.

And it has been quite strange, really. But everyone's so friendly, even though we've never met in person,

it's really lovely

Will we do it again?

No, I don't think I ever want to do it again. It was very stressful, but now it's all over with I'm just so proud of myself, yeah.

What about you?

I do, I'm excited, I like the hat after all, I think I'll take it home with me.

Yeah.

And the community, it's just so strange thinking we finally all got together and everyone actually, everyone is

Everyone's real.

Everyone's real and most people are our age. I was expecting, I don't know what I was expecting.

A lot people to be younger perhaps, but they're all our age which I think is great.

So the old birds can do it.

Yeah. Well, I don't know really what else to say, except that I'm so excited.

I'm so excited today. It is lovely.

Well I'll take lots of photos.

Yeah. That's it. Sorry.

Phillip McCann & Colin Shaw

So what did you study online?

What did I study online?

Why?

Why... I actually studied online simply because one, I have essential skills problems and also dyslexsia

and found Ultraversity was a very good way to study using technology

and therefore could use my weakness as a strength to study

Yeah, I found that. I've done it because I just felt that I could go in whenever I wanted to

I can put the time in when I wanted to and I wasn't in that set routine

when you have to go to a college or university for those set lectures, so that is why I studied online.

And that is actually a very good benefit, because like yourself, I mean, as I said I had the essential skills issue

but again I was able to come in, cope and do the work at times that suited me and family

because I was there to care for one of the family members and I find that studying online at times was a godsend.

And I think for the workplace there is a benefit because they don't have to release you during work time,

because do you find you've got any time at work?

I actually got no time off of work at all, so any work I've done was done at home or in my own time

and obviously that was an advantage to use Ultraversity to do so.

Yeah, I found that as well, very beneficial.

Barbara James & Shirley Murison

OK

Yeah, I think the last year did help us go on when we were online

I definitely think that the interaction between all the members in our learning set was beneficial

it was useful to bounce different ideas off people,

it was useful to have some feedback from other students about the work we were doing,

and I don't think, I think without that interaction we would have found it very difficult to continue

through to the end and to succeed as we have.

I think the online community, it helped you, you didn't feel so isolated

because when people, other researchers had problems they posted it

and you could, you could connect to their problems.

I agree with you and I think there were many people online who were very supportive

and were always there to give advice and to give critical feedback when it was needed

I think I would have found it very difficult, especially the last year

if I hadn't had people in my learning set questioning what I'd written

and giving me the opportunity to answer their sort of criticisms with my own thoughts and feelings

and in that way I think my overall performance improved because of it.

Yes, I also think as well where sometimes I used to think that you had a small little silly problem

somebody would post the same problem and I'd think, ahh, you could relate, really relate to it.

and definitely the criticism that you had, the constructive criticism helped you in especially in the last year

Yes, I agree.

with your reflection

It was very difficult to take sometimes

you know, it was, you would feel quite sort of hurt sometimes by it, but you overcame it and you moved on

and you were definitely improved because of it.

What surprised me was the friendliness that developed on the online community

and though you've never met a lot of the people

you felt that with the postings, that you did really get to know them.

Yes, they became your friends

And for us in the management community we actually met several times over the period of the three years.

and I made life-long friends through being on the online community and I think that's wonderful, you know.

One of the benefits I also found was when you're insular in your own school, you also read the problems that are in other schools

and you could, you could identify with them and it made you realise well you're not alone.

No but in many schools, all school communities are quite similar

and that the degree and actually talking to people about the degree you realise that

you were sort of a valued member of the community in which you work.

Enough, is that enough?

Jill Felton

You have a different journey, so would you like to tell us about it?

Yes, well I was an LSA in my local primary school where my children went for about 10 years

and they always encouraged me to be, to go into teaching because I used to teach groups as an LSA,

I wasn't actually a classroom based LSA

then I found out from my staffroom for this degree

and in the third year of my degree, I managed to get a place on the Registered Teacher Programme

and with the wisdom of my school, at the same time they actually gave me a class to teach at the same time,

so I was teaching a Year 5 class doing the third year of this degree

and as I say, I started a Registered Teacher Programme, so I was doing sort of three things at the same time,

which was quite hard but I managed to get through the year, and I am also a mum of four children as well.

It was very hard, but the support of the people on my learning set was fantastic

They were all saying "Are you mad? Can you fit anything else into your life?"

But after the degree finished, they then fast-tracked me on to the GTP which is the Graduate Teacher Programme,

and I am due to qualify as a teacher after Christmas.

So I literally finished my degree in July and I will be qualified as a class teacher,

although I have been teaching as an unqualified teacher for virtually two years now.

So it is a really special achievment today, then?

Yes, I was really pleased actually to get a first as well, I was amazed.

I mean, it did take a lot of hard work, and tears sometimes and the support of my family was fantastic.

But, yeah I am really pleased to have made the journey and got there in the end, so yeah, it is fantastic.

Thank you.

Denise Binks

Hello, I am Denise Binks. Hello, I am Denise Binks. I've... I really don't know what to say, we really have to start thinking what to say really.

To begin, when did you first found out about this degree?

Shall I start off by when I was a child?

Because when I was a child, I really wanted to do a degree

but I had to leave school and start work, that was the culture of my family

and so I then went into working for a travel agent, I was a travel agent for quite some time

and I did my exams for travel agencies. But then I had a career break to have the children

and at that point when I wanted to go back to work, I had no qualifications to show exactly what I could do.

So it was then that I found a leaflet on my desk about the Ultraversity

and it seemed the obvious answer for me, because it meant that I could still continue to work but at the same time do the degree.

So I took the first steps into doing the degree.

I found it very good, because it was using my skills in workplace and therefore it was workplace orientated

and we could structure the degree around what we were doing in the work. So it didn't feel as though I was doing two things

and I also found the online community was very good because it meant that we could find we were all there together

there are other people like myself who had children, who were out at work and they pushed me on,

so when I said "I can't do this because I've got the children",

I found that I was doing it because other people were in the same boat as I was.

Can you tell us about your role?

I started off as ICT technician, LSA, and at first I was simply looking after the computers

my rôle has changed through doing the course I'm now an ICT teacher

and I'm looking forward to trying to qualify as a fully qualified teacher.

Thank you

OK then, sorry.

start telling me about the major gain doing the degree for you, OK?

Dean Ibbotson

The degree helped me to gain my teacher status at my employment, George Dixon.

I'd been going as a teaching assistant helping in mainly ICT and science.

As I progressed through the degree, how can I put it, I gained some certain skills that I was using at work

it helped me to gain confidence, and it just boosted me in my work, really.

So I was put forward to possibly teach as an instructor

I started teaching just one or two lessons on my own and now, this year, I was put forward to doing a full time teaching

teaching, full time teaching science and ICT. So this is basically it.

Any other questions? 23

So when you left school, what kind of qualifications did you have?

I left school with 11 GCSEs. I went to a college and studied PE and Geography at A-level.

So I finished ending up with two A-levels coming from college and I was working on building sites initially!

And then a friend of mine got me a job at the school where I work right now.

After a year I have been at the school, I got on to the Ultraversity course and then it's just taken off from there to be fair.

Maureen Slack

Tell me about your contribution then to the community.

I personally got a lot out of it. I mean, I like speaking to people in an online community

and I liked being able to help people. I chatted a lot online to people and emailed people

and I felt that I was able to support other people who were perhaps less confident in online communities

and I think, that they appreciated that. I got a lot of positive feedback from that.

We all learnt from each other, and by opening up discussions in FirstClass, we got to know one another on a personal level

which we then took a stage further by meeting up at various locations and that built up a really good relationship with other students.

So, I felt that helped our learning experience because we trusted each other

because we had met on the online community and then in person,

we could share our work and our experiences perhaps at a deeper level.

You also got humour into it.

Oh yes, yeah, we had lots of laughs, I mean, we shared sort of funny emails and we talked about what we did at work

and the silly things that the staff did at school to annoy us. We brought our own personal experiences in to it

and all of that helped us to develop this sort of deeper relationship which I felt, personally helped my learning experience

but I think also helped other people who were perhaps less confident.

I mean, I could see over the three years how people's confidence grew, because we were such a friendly bunch of people

and we got on so well together and we trusted each other.

someone & someone

What do feel that you, that's been your major gain working with Ultraversity? What do you think you gained?

Initially, the gain was being able to do a course while I've got two children and managing

and also being able to work as well

How did you manage the fitting in the course as well as working?

Well I think that it makes you really good at time management because you have to juggle, haven't you?

You've got to juggle your children and your workplace,

but the great thing is, is learning from experience and taking that experience into …

From everybody else's views, when you go online and you gain experience from everybody else's views

… and work experience as well. You know, going in to work and sharing your experience with colleagues as well.

Did you find that, that helped you?

To be able to compare my experiences with their's and researcher's online

it really helped me to re-learn what I already know, if you like, to confirm what I already know

and then cascade that information back down to other work colleagues as well, to help them in their role

I just could never envisage myself here, with a degree, because I always thought that I wasn't an academic

because the books didn't mean much to me, but actually reading and then putting everything into work experience

it came alive to me. Is that what happened to you?

It did to me. And I think the main, that one of the things that really helped me when I was working with Ultraversity

was the learning journal, logging everything down and every experience

I still do that, do you? Do you still do that? Yes, I do.

It's very hard to get out of that habit and I think it is a good learning curve

to have that and to be able to refer back, whether it's written or whether it's tapes or whatever. You got it there and that helps.

And it's great evidence as well, isn't it for everything you do: in the workplace, home learning, its great.

Michelle Townsend

My name's Michelle Townsend and I've just recently achieved my degree in Learning Technology and Research through Ultraversity

It was a difficult journey really, but manageable due, thanks to the support really of my family and also my work colleagues.

I work in Grimsby, North East Linconshire at a childrens' centre

which is a Sure Start initiative run by the government.

I was very well supported by the head of the centre throughout my degree, she actually paid for the training completely

and was very supportive in any research that I needed to carry out during the degree.

As a result of achieving this degree, I am now acting family services manager at the children's centre.

A brief history of what of my life at the children's centre is:

I went there in the year 2000 as a nursery nurse, working in kind of outreach work.

I then became the training coordinator three years later,

where I worked with parents and families to try and help them achieve their potential basically,

helping them achieve literacy, numeracy skills, also helping them get back into the workplace.

So it was a real rewarding but difficult task, as I work in one of the most deprived areas in the country.

but you know, I am just really grateful that this route was available to me because

it was a long-term aim of mine to achieve a degree,

but there was no way I could afford to give up my job and go and study for three years full time.

So when the flyer fell on the staffroom table, it was really you know the answer for me, it was the right route.

And that is me, really.

[P10] Inter-Disciplinary Inquiry-Based Learning (IDIBL)

Aug 01, 2007 to Jul 31, 2013

Development of a framework model for undergraduate and postgraduate work-focussed learning based on the Ultraversity work, but intended to support curriculum innovation throughout the University of Bolton.

> **Aim**: To design and develop a whole university framework for work focussed learning.
>
> **Reflection**: Developing the IDIBL project meant taking a successful project, Ultraversity, and attempting to make it a whole university development – a huge challenge. Explaining the various aspects of this challenge meant exploring new theoretical perspectives and articulating the rationale for the model we designed for peer-review. This included learning about cybernetic theory, patchwork media, organisational analysis, change processes and disruptive innovation and analysing the findings of the project in this light. The approach was of participant action research and methods of survey, interview and interpretive phenomenological analysis were applied to the evaluation phases of the cyclical inquiry.
>
> **Contribution**: My role was of co-developer, working closely to establish aims & values, design the curriculum, seek validation, organise, teach & mark work, operate quality mechanisms. I also designed the web site and fliers for marketing, sought meetings with stakeholders to market the course directly, worked with staff to disseminate ideas within the university, undertook research to establish evidence and co-wrote academic papers and made presentations at conferences. My part: 25% (with Stephen Powell and others)
>
> **Originality, impact and importance**: The project was based on the experience of Ultraversity, but broke new ground by taking a whole university framework approach. It led to wholehearted adoption by some colleagues, whilst others appropriated parts of it for other courses. Its importance was in recognising the conditions under which work-focussed learning could prosper.
>
> **Evidence**: The impact of cybernetic theory (Beer 1985) on finding explanations for design success and failure in systems of education was published in the journal Campus-Wide Information Systems (Millwood and Powell 2011).

The rationale offered for validation of the framework in 2008

The inter-disciplinary inquiry-based learning framework (IDIBL) provides a pedagogic, organisational and assessment structure which can be used as a basis for course approval through modification of appropriate sections in this document by departments who identify an opportunity for an inquiry-based, work-focussed programme.

This should provide an agile procedure for introducing new courses, which intend using the innovative approaches developed for IDIBL. It remains for each course validation to identify a rationale for professional engagement, viability and delivery.

The framework is designed to offer a combination of pedagogical approaches, which together provide a different route for academic study and appeal to people who are committed to their. The course will widen participation by satisfying learners' whose need is for flexibility with time, place and pedagogy. More specifically this could be because:

- They need to continue in full-time paid employment whilst they study;
- They wish to make their study directly relevant to their work;
- Family commitments prevent their on-campus attendance;
- Geographical location or poor transport links makes campus attendance difficult;
- They seek to develop further their communicative creativity and technological understanding as a complete professional;
- Traditional examinations and academic essay writing are either intimidating or uninviting;
- They seek the company, support and intellectual challenge of fellow students rather than studying alone;
- They seek the advantage offered by technology to enjoy the possibility of work on joint ventures and studying collaboratively.

The modules contained within the framework focus on process, and generic concepts and outcomes rather than subject content. Through a process of negotiation between the individual learner and the course staff, a personalised inquiry will be developed to include learning activities and assessment products that meet the module requirements and informed by the learners' professional practice. All learners in a cohort will be carrying out their inquiries and develop assessment products to the same set of milestones. Thus they are expected to provide support and challenge to each other and travel a common path in spite of the personalisation of their study. The design encourages different perspectives from diverse professional and academic disciplines to be exchanged.

Learners will align and defend their attainment against module learning outcomes and with reference to competencies or national standards relevant to their work context. Learners are expected to look critically at their work setting as a source of knowledge and experience from their own experience, colleagues' experience and reference documents. This approach puts responsibility on the learner to maximise their effectiveness and efficiency through reflection on their work practice scaffolded by module requirements that are intentionally directed to enhance the quality and outcomes of work.

The framework is designed to enable progression by learners from a Foundation Certificate of CPD at level 3 through to level 7 Masters course. Common throughout the framework is an inquiry-led, work-based approach to learning that meets students' progression and continuity needs throughout.

There is a growing realisation that practitioner knowledge can inform academic knowledge. This proposal recognises and supports a realignment of knowledge acquisition and sharing and a re-alignment of roles for staff in higher education and the practitioner in society.

As a backdrop, the 2006 Leitch report examines the UK's long-term skills needs and identifies increasing employer investment in higher level qualifications to meet the target of more than 40% of adults skilled to graduate level up from 29% in 2005. The approach outlined in this document is one route that should be attractive to employers and employees alike in that it offers a cost effective approach for students as they can gain their qualification at a full-time rate of study. It is attractive to employers as the focus of student study is directly related to improving their work performance.

The development and outcomes of this work are more fully reported on the Work Focussed Learning web site.

[P11] Report on good practice of innovative applications of learning theories in TEL

Apr 30, 2013

A report on learning theories and how the design of innovations in technology enhanced learning may be reviewed through a multi-levelled stakeholder analysis.

The HoTEL Support Action aimed to contribute to more effective, holistic and faster innovation cycles in European Technology Enhanced Learning (TEL), focusing on the design, testing and validation of a new innovation working method.

This document sets out the learning theories which influence innovators, identifies the new learning practices supported by TEL in higher education, professional learning and informal learning, and offers a multiple stakeholder analysis for TEL innovations in learning & education.

Educational innovators should benefit from this document as a guide to effective analysis, decision-making and implementation.

> **Aim**: To clarify the accepted learning theories and explain their connection to theorists, disciplines and paradigms.
>
> **Reflection**: Creating this document was a challenge for me in making sense of the diverse theoretical and conceptual positions and disciplinary backgrounds of learning theorists and to propose the application my own stakeholder analysis to innovations in technology enhanced learning - but it helped to bring all these things together for a real audience and with peer review.
>
> **Contribution**: I exercised analytical and visual design skills in the construction of the conceptual diagram and contributed the statements about the complex, contested and dynamic nature of learning theory. I also tidied up and commented on the stakeholder analysis for innovation designers. My part: 80% (with members of the HOTEL project team).
>
> **Originality, impact and importance**: This work includes a new synthesis of key theorists and their ideas, highlighting disciplinary background. It has been widely reported as part of the Hotel EU project and achieved widespread dissemination and impact. It is intended to address an EU identified problem of educational technology innovators who are actively developing without a full understanding of the scope of learning theory and its problems in relation to technology.
>
> **Evidence**: The report is a deliverable of the EU funded HoTEL project (Millwood, 2013a). Widespread dissemination and impact is evidenced by the commentary on my blog (Millwood 2013c) and a number of adaptations and translations into other languages.

Appendix 2 - People

Colleagues who have collaborated, influenced and led my practice

Bob Lewis

Bob employed me in 1990 to join the Computers in the Curriculum Project at Chelsea College in the University of London

Although Bob was my director for only one year, he made a great impact on me in my first year as a researcher working in higher education. He was an inspirational, technically-minded, hands-on person who could also reflect and theorise the issues we faced very effectively. His approach to managing the team was empowering, but also he had clear ideas of the action research process we should be engaged in.

He impressed me with his early grasp of the problems of interoperability and his determination to solve them. He also clearly analysed the challenges of artificial intelligence, pointing out that the difficulty of modelling the mind was immense and not likely to be solved soon and that our computer resources were not technically advanced enough to match the complexity of such a model (as might be speculated).

Bob invited me to collaborate with him after he left Computers in the Curriculum, in teaching on residential courses and, most enjoyably, on an international UNESCO summer school in Yugoslavia.

> **Reflection**: Bob's analysis of the reasons for lack of progress in artificial intelligence was prophetic and helped me to avoid spending too much time investigating intelligent tutoring at a time when it was under serious consideration and instead encouraged me to focus on the decision-making and responsibility of learners in using the computer as a tool.

Margaret Cox

My director from 1981 to 1990 and collaborator in more recent times, Margaret has inspired me with her criticality, intelligence, knowledge and her faith in people.

Margaret replaced Bob Lewis as head of the Computers in the Curriculum project in 1981 and I worked with her closely until 1990. Her experience of developing software extended into the seventies as part of the National Development Programme in Computer Assisted Learning funded work at the University of Surrey.

We often debated about the best strategies and on one occasion I called her 'Mum' in the heat of an argument!

> **Reflection**: Margaret taught me to be pragmatic, caring and nevertheless concerned to do the right thing at high levels of quality. I learnt how to formulate research with rigour through her advice.

Royston Sellman

Royston shared an office with me for much of my time in the Computers in the Curriculum project at Chelsea College and made an excellent colleague and critical friend.

Royston is the most down to earth character who loves his work in solving simulation problems and designing software. His talents ranged from mathematical analysis to a real understanding of the nature of programming. Royston raised my game with respect to the best way to programme and opened my eyes to a theoretical world of computing that I had not encountered. We would argue about the relative merits of Pascal, Smalltalk, Lisp, Logo, Basic and Hypertalk. Royston's groundedness also helped me avoid the worst excesses of naivety and idealism

> **Reflection**: It was discussions and debates with Royston that deepened my knowledge of quality in programming and a pedagogy of computing.

David Riley

I worked closely with David from 1983 until 1990 - his friendship, together with an inquiring and methodical mind gave me opportunity to discuss many ideas in depth ranging across pedagogy, design and management.

David had a particular interest in modelling and background in geography leading simulations of gas pipelines, software for evaluating location decisions and ultimately to the proposal to develop the Planet Earth CD-ROM as part of the Renaissance Project.

Together we explored how best to offer the learner a toolkit to work with multimedia in a constructivist sense.

We also worked to offer design advice to colleagues in the Computers in the Curriculum project.

Finally we saw that simulation, although valuable, did not achieve the depth of understanding that modelling could.

> **Reflection**: The decision making inherent in simulations we created was important but the creativity and analysis demanded in modelling itself was more powerful for learning.

Sam Deane

Sam worked with me as a school student in a summer job in the late eighties and later as a colleague in the mid-nineties.

Sam accompanied his friend from Hampstead School to meet me at the Computers in the Curriculum Project in Chelsea around 1990. His friend had been recommended to me by my first wife Ursula, then head of mathematics at the school, to consider a summer job as a programmer with us. In the end Sam came instead!

Later, after completing his degree in Computer Science at Bristol University, Sam joined Ultralab to program some of our most innovative pieces of software for learning. Together with Alice Mitchell we designed immersive software for language learning.

He left to continue a career developing substantial games software for some of the major industry players and remains just in touch even now.

> **Reflection**: Sam's influence on me was profound, because he had delved deeper into the issues of software development and yet remained in touch with the wider issues of designing tools for learning. I began to understand some of the profound challenges of developing software in a team and how to manage a quality process.

Stephen Heppell

I first met Stephen in the days of HEADNet (the HyperCard Educational Application Developers Network) in 1988. Subsequently we worked on the Renaissance project to develop CD-ROM multimedia. I then joined Stephen at Anglia Higher Education College in 1990 and worked alongside him to develop the Ultralab as a research and development centre until he left in 2004.

It is safe to say that Stephen Heppell's thoughts and actions are the biggest influence on my mature practice.

I consider the agenda he set for Ultralab as one I fully subscribe to, and his clarity of purpose to be simply inspirational.

The values he proposed of inclusiveness and caring have become my own and the example he set in practically exhibiting such values is the standard I aspire to. His willingness to roll up his sleeves and make things happen was infectious and his ability to leave the past and look forward unparalleled. It has been my pleasure to have been his critical friend, but rarely have I found fault beyond the trite. He was always generous in listening to my sometimes overly analytical perspectives, but our partnership was at its best when I found myself complementing his talents with my own.

> **Reflection**: Stephen introduced me to concepts of social justice, learner-centredness, multi-modality, vision, the benefits of neologism (!) and the confidence to take action. I learnt how to manage change, manage people and direct innovation under his leadership.

John Davitt

John has been a family friend and a professional agent provocateur for my thinking. His analyses are creative and insightful, but he has always welcomed my critical friendship.

John's first book 'New Tools for Learning' is subtitled 'Accelerated learning meet ICT' which describes perfectly the effect of good conversation with him. I have been learning with him for twenty years now, and every time new ideas blossom. His sense of overview of the ICT scene is profound and clarifying, with useful critiques and clever catch-phrases which act as aide -

memoires. My favourite is 'S&N' which stands for subtlety and nuance - a lens for examining technology which so often is more like a digitally blunt instrument compared to the refined perception of human touch, hearing, sight and vision - to sniff nothing of smell!

> **Reflection**: John has helped me develop practitioner theories for my design work and hone them with critical debate.

Carole Chapman

Carole collaborated with me from 1990 to 2006, working together to design educational materials, implement creative online projects and develop large-scale action research. She understood management as a service in the support of many of the projects that Ultralab undertook.

Carole's finest asset was her ability to see things from a young person's point of view and to appreciate the power relationships inherent in schools and institutions. She anchored many people in Ultralab, supporting them with critical friendship and moral support. Her determined willingness to take on sponsors and civil servants and argue the case for the radical innovation that she proposed was inspiring.

> **Reflection**: Carole inspired me with her no-nonsense hard work, unwavering learner-centred perspective and values-oriented thinking. I learnt from her about social science, gender and social justice.

Dai Griffiths

I first worked with Dai in 1992, translating our Workrooms software into Welsh, Catalan and Spanish. We subsequently worked on the Etui project to invent a toy, and finally came together again at the University of Bolton in 2007, and Dai is now my director of studies!

Dai introduced me to a perspective on culture in learning that I had no concept - the separation of nation and language and culture. His linguistic knowledge helped me understand the challenge faced by minority language groups and together with Stephen Heppell and Greta Mladenova we published on this topic. The discussions and designs we made regarding the Etui toy for early learners built a more profound base of practical, developmental research. Dai's work in the TENCompetence project combined well with my own in developing competency frameworks and interactive software for Macmillan Cancer Support.

> **Reflection**: Above all else, discussions with Dai on epistemology provided a valuable reflective debate which has led to a clearer understanding of knowledge for me.

Tom Smith

Tom worked with me in Ultralab in the nineties, bringing a multi-disciplinary no-nonsense approach to design. He had particular talents to create original visual material, understand visual design and 'get' a bigger picture of what it all means.

Tom joined Ultralab as a volunteer after reading about us in a magazine and realising we were just over the road! His determination to create complex and powerful server software mixed with his clarity about design issues inspired me to do the same. We shared much analytical thinking to make sense of the online, multimedia, interactive and participative opportunities that burgeoned in the mid-nineties.

> **Reflection**: I learnt to see through surface meaning and understand the motives and forces that shaped people's behaviour through discussions with Tom.

Alice Mitchell

Alice was the new head of the Anglia Polytechnic University Language Centre when I first met her. She was a close collaborator and friend working on language learning software for business.

Alice was a very articulate and high quality teacher, developer and pedagogue in language learning.

We worked together to advance her concept of TecLab - a re-invented language lab linked to and funded by the Training and Enterprise Council which focussed on vocational language learning. Her determination, clarity of vision and extensive knowledge of what worked in language learning made for a very productive partnership.

We created innovative interactive video materials on the computer using multiple text track movies in Apple's Quicktime software (my contribution) with engaging social and business plots in the style of a soap (Alice's contribution) with a substantial coverage of learning standards in French and German. The resulting comprehensive learning resource was titled Ultra-Language-Lab and was successfully sold to a commercial provider of the time.

Later we worked with Sam Deane for the Teleste company directed by Pekka Lehtiö to create an immersive environment for language learning, which pre-dated Second Life by many years.

Alice has sadly passed away and is much missed.

> **Reflection**: I learnt from Alice a deep understanding of learning languages which clarified for me the need for some rote learning in a motivational context to learn basic facts and correct pronunciation together with a more analytical and creative approach for the deeper structural knowledge.

> **Reflection**: The techniques of multiple text track interactive video materials were completely new, as was the HyperCard fuelled technique for their manufacture, allowing editing of detail and 'recompilation' to achieve accurate results - vital for language learning.

Pekka Lehtiö

Pekka was a director of Teleste, the Finnish company responsible for the development and manufacture of Tandberg language learning labs which were perhaps dominant at the time. He approached Ultralab to invite us to develop a new language learning environment using multimedia computers.

He notably explained to me the idea of a 'Chinese contract' which was designed to offer the most positive outcome for both customer and client even if the project was curtailed.

We negotiated such a contract, and Sam Deane and Alice Mitchell worked with me and others to develop Aardvark - software to allow the development of three dimensional navigable spaces where linguistic challenges would be confronted in relevant and meaningful contexts, but with considerable freedom to explore.

These were very early days for such ideas, especially our intent to make the spaces constructable by language teachers rather than developers. In that sense it was a forerunner to such spaces as Second Life. Pekka encouraged us to be ambitious but also attempted to maintain some control over our delivery milestones! At the end of the project he invited us to Finland to present over two days to the development team based in Turku.

> **Reflection**: Pekka with his patient and generous attitude taught me much about the challenge of large scale development and managing a relationship with a commercial partner.

Stephen Powell

I have worked with Stephen since 2000, when he joined the Talking Heads project and later in 2003 when he led the Ultraversity project. We then continued to work together on the IDIBL project at the University of Bolton.

2011 Stephen Powell.jpgStephen's inquiring, direct and business-like manner has helped immensely to focus on publication and the completion of this thesis - he has acted as my main formal and informal supervisor (as the university changed its mind about the legitimacy of that rôle when you are colleagues and students). His interest in the systems of higher education has expanded my knowledge through the debates, planning and co-research we have undertaken. As a supervisor of my PhD he has helped me to plan milestones, provide moral support and shared his enthusiasm to see it completed. There are few people who have such a good and objective knowledge of the working of a university as an enterprise.

> **Reflection**: I am particularly pleased to have developed my knowledge of Cybernetics through working out the ideas with Stephen and applying them to our mutual experience and practice. We also tackled several social science and design research methods together, gaining confidence from sharing the challenge.

Others

There are many more who have been mentors, close collaborators and influences, but I have had to limit detailed reflection to some of the most influential. Those listed here (and others I am sure to have missed as my memory fails - tell me and I'll correct this!), have provided moral support, critical friendship and intellectual stimulation. Sometimes even the briefest connection has made a major impact!

Abject apologies to anyone who I have left out or misrepresented - it probably means you were so close, I have failed to notice, like water to a fish :)

Thanks to:

My supervisors, formal and informal: extra-brother Stephen Powell, Keith Alexander, Dai Griffiths, Bill Olivier, Margaret Nelson, Gill Green.

My family

My mother Elizabeth and father Richard who laid the foundations of a life-long passion for education, mathematics, science and appreciation of the arts, crafts and music (to say nothing of some manners, reading and writing, commitment and confidence).

My sisters Elizabeth and Bridget and brother Seán, who debated minutiae for every minute of my childhood and still haven't given up, making me what I am.

My teachers at school, too many to mention, who made me think and gave me confidence.

My companions in my teens in Dumfries (Scott Kerr, Chris McKinnell, Judith Gallon, Jimmy Archibald) and in my late teens in Barking (Terry H).

My flatmates at Kings College London, Steve Robson and Steve Wood (Wilf) and student friends John Hughes, Cathy Sims, Susan Beacham & Richard Wakeford.

Ursula Millwood, my first wife, who suffered my obsessions for the first half of my career and partnered me in many adventures both professional and personal including the gift of my first two children, Patrick and Ben.

School teaching

Alistair Buckenham, Mathematics teacher at St Marylebone Grammar School in 1976, who inducted me into teaching and helped me find the attitudes, values and practices which have endured ever since.

Oleg Liber, Mike Humphries, Europe Singh, Brian Harrison, Keith Philip - the mathematics department at Scott Lidgett School who supported my growing interest in developing learning materials and assessment.

Computers in the Curriculum

Bob Lewis, Peter Smith, Margaret Cox, David Riddle, Deryn Watson, David Riley, Grant Alderson, Royston Sellman, Angie Donoghue, Sophie McCormick, David Squires, Keith Shaw, Diane Moody, Eva O'Donoghue, Colin Smith, Alan Edis, Marianne Atherton, Jean Seechurn, Terry Hinton, David Johnson, Jonathan Osborne, Joan Bliss, Paul Black, Margaret Brown, Kath Hart, Jon Ogborn, Ian Kilberry, Angus Willson, Steve Hurd, Ken Randall, Margaret Brown, Kath Hart and many others in the Computers in the Curriculum Project, Educational Computing Unit and Centre for Science and Mathematics Education at Chelsea College (subsequently King's College) throughout the eighties as I grew from school teacher to education lecturer and researcher.

Long term friends amongst colleagues I met in the '80s and '90s including Ian Sillett, Gary Stevens, Tony Parkin, Steve Oram, Mike Aston, Diana Freeman, Mike Bostock, Peter Bratt, Tony Kiddle, Vivi Lachs, Phil Langshaw, Norbert Pachler, Mary Webb, David Hassell, Bill Tagg, Tony Wheeler,

Ultralab

Stephen Heppell, Ann Constable, Stan Owers, Sheila, Andrew Wood, John Sharkey, Sam Deane, Anne Bradbury, Nikki Gamble, Nick Easingwood, Heather Crouch, Chris Curran, Geoff, Sue Clacher, Tom Smith, Lys Johnson, all from early days as Ultralab was formed and then all my colleagues in Ultralab in the period until 2006 when it closed, some of whom are in this photo:

My best list of all of them is:

James Brain, Tony Browne, Lori Camm, Craig Carey, Carole Chapman, Ann Constable, Mark Constable, Antonia Coppen, Andy Cunningham, Sam Deane, Martin Doherty, James Dorling, Jonny Dyer, Matthew Eaves, Tim Ellis, Colin Elsey, Jonathan Furness, Alison Gee, Jean Gray, Claire Gregory, Andy Grey, Maureen Gurr, Rhys Harries, Colin Harrison, Graham Hart, Michael Hartley, Melissa Heppell, Stephen Heppell, Clare Ingram, Jean Johnson, Lys Johnson, Sarah Jones, James Kadirire, Ioanna Kita, Kostas Kokkinopoulos, Geraint Lang, Hal MacLean, Paul Martin, Lesley McGuire, Hilary Messeter, Alice Mitchell, Greta Mladenova, Malcolm Moss, Gerome Oldfield, Stan Owers, Simon Patton, Shirley Pickford, Nick Platts, Stephen Powell, Leonie Ramondt, Gina Revill, Gill Roberts, Anthony Russell, Hamish Scott-Brown, Alan Seargent, Teresa Selvey, Beverley Simpkin, Andy Simpson, Matt Sisto, Manoah Smiley, Tom Smith, Tom Stacey, Vicki Swan, Gail Taylor, Ian Terrell, Kevin Thompson, Craig Tindal, Ian Tindal, Richard Tydeman, George Variopoulos, Alison Wade, Weiya Wang, Jean Whitehill, Tim WIlliams, Lindsey Wingate, Rex Wingate and Kirsty Wooldridge.

Greta Mladenova, colleague at Ultralab and my second wife who inspired much creativity, worked tirelessly, suffered my pedantry and raised the third gift, Sasha.

My PhD students (and colleagues), from Ultralab days - Carole Chapman, Abraham Doron, Nili Naveh, Anthony Russell, Geraint Lang, Lesley McGuire, Mark Penny and my supervisor colleagues Gill Robinson and Vernon Trafford.

Colleagues at Anglia Ruskin University - Roger Clark, Colin Harrison, Woody Caan, Mike Salmon, Dawn Hillier, Diana Powell, Tony Powell, Robin Smith, Michael Haynes, Mick Betts, Gina Wisker, Richard Winter, Maidi Brown, Sharon Waller and many others, and those on projects - Marc Blasband, Josep Blat, Mimo Caenepeel, Steve Lay, Robert Harding, Joachim Wedekind.

Nick Billowes, Vince Ham and Derek Wenmoth who built and sustained Ultralab South which become Core Education in New Zealand with Ali Hughes, Ronnie Davey, Julia Atkin, Carole Moffatt and others at Core having a huge influence on my thinking. Also Paul Rodley at Christ's College, Paul Cathro, Murray Leach and many other New Zealand colleagues.

Core Education UK

Maureen Gurr, Malcolm Moss, Alison Gee, Sarah Jones, Rex Wingate, Graham Hart who helped form Core Education UK, and Steve Capper who helps sustain it still.

University of Bolton

Oleg Liber, Julie Halliwell, Mark Johnson, Paul Hollins, Stephen Powell, Bill Olivier, David Sherlock, Scott Wilson, Simon Grant, Wilbert Kraan, Adam Cooper and all the others in the Insitute for Educational Cybernetics at the University of Bolton, including PhD students I help supervise - Ian Wilkinson, Michelle Singleton, Lynn Campbell, Tim Goddard, Kesiena Clement-Okooboh, Roz Fox.

Margaret Nelson has offered her experience and support freely as I have struggled with this PhD, and acted as a critical friend too many times to count and connected me to my supervisor, Keith Alexander. Other influential colleagues at the University of Bolton include Ebun Akinsete, Mohammed Tammo, Bobby Nisha, Donna Vick, Grainne Gordon, Hilary Birtwhistle, Rob Campbell, Paul Birkett, Gill Green and Sue Burkinshaw, Mike Lawrence, Mike Lomas, Peter Marsh, Marie Norman, Patrick O'Reilly.

Professional

Information Technology in Teacher Education (ITTE) colleagues of long standing including Martin Owen, Avril Loveless, Sarah Younie, Tony Fisher, Bob Fox, Mike Hammond, David Benzie, Graham Jarvis, Bill Gibbon, Jon Coupland, Roger Keeling, Sue Brindley, Steve Kennewell, Chris Higgins, Peter Twining, Michelle Selinger, David Longman, Libby Jared, Suresh Jethwa, Margaret de Jong-Derrington, Angela McFarlane, John Potter, Bridget Somekh, Neil Stanley, Peter Twining, Jean Underwood, John Woolard,

Other colleagues in the world of education that have provided support, advice and provocation include Gabriel Goldstein, Brenda Gourlay, John Davitt, Merlin John, Eileen Freeman, Bryn Holmes, Brendan Tangney, Clive Holtham, Sergei Christochevsky, Andrei Fedoseyev, Todorka Damianova, Leo Højsholt-Poulsen, Paul Clark, Eddie Gulc, Andy Black, Terry Freedman, Steve Moss, Charles Crook, Leon Cych, Doug Brown, Roberta Weber (who I should have got to be my supervisor), Roger Carlsen, Elizabeth Oldham, Thomas Winkler, Marilyn Leask, Darren Leafe, Sandra Crapper, Sue Owen, Keri Facer, Dylan Wiliam, Christina Preston, Mary Ann Kernan,

Hidayah Amin, Stephen Carrick-Davies, Drew Buddie, David Garland, Stephen Capper, Linda Thompson, Hannah Davies, Richard Green, Mary Harris, Tina Preston, Dave Smith, Tore Hoel, Vana Kamtsiou, Joy Hooper, Bill How, Simon Humphreys, Paul Lefrere, Gillian Lovegrove, Peter Maher, Tim Marshall, Harvey Mellar, Peter Mitchell, Sean O'Sullivan, David Baugh, Ian Wilson, Julian Coultas, Mike Rumble, Seb Schmoller, Jim Shelston, John Siraj-Blatchford, Lampros Stergioulas, Dan Sutch, Ralph Tabberer, Tim Tarrant, Matthew Taylor, Sydney Thornbury, Jamie Tuplin, Sue Walton, Mick Waters, John Williams, Theo Wright and Arthur Tatnall.

Partners in the professional and business worlds including Alan Bennett, Chris Binns, Bob Rogers, Alan Matcham, John Rudkin, Michael Ambjorn, Tilly Blyth, Cathy Derrick, Greg Childs, Iona Walters, Andrew Chitty, George Auckland, Alan Greenberg, David Heath, Caroline Hook, Aynsley Jardin, Steve Moore, Andy Pendry, Bob Rogers, Tarek Shawki, Barbara Strebel, Conrad Taylor.

My good friends in Brentwood in the Labour Party, Educating Brentwood, CND, The Brentwood Arts Cinema Club, Brentwood Community Print and pottery at The Fold. The many friends made at the Royal College of Music.

Personal

My extended family of extra-brothers-and-sisters-in-kind: Detty, Stephen Powell, Joy Hooper, Jed Burroughs, Hazel Bartlett, Tony Bartlett, Sally-Anne Maidment, uncles, aunts, nieces - Sineád, Maeve, Catlin, Tess and extra-special-niece Lily and nephews - Watty, James, Hal, James Burrows, extra-special-nephew Martin Bartlett have all supported me and egged me on.

Finally I must thank my fantastic children, Patrick, Ben and Sasha who have inspired and exemplified so much of what I value in life through their own (and independently developed) moral framework, determination and sheer hard work.

Appendix 3 - Contribution to practice email & letter

This was the email sent to collaborators inviting them to corroborate my estimate of contribution to practice with them:

> Dear XXXX, sorry to be so out of touch - it would be good to meet some time and to catch up.
>
> In the meantime, I need a favour.
>
> Can you agree and sign the attached letter and return, either in the post or digitally?
>
> A great man once told me that I should "Leave it to the last minute, because it will only take a minute".
>
> I have never failed to take that advice.
>
> The Research Committee meets today at 14:00 GMT to consider my case for registration - so that's 140 minutes more than usual.
>
> Nothing will fail if I don't have your letter, but it would be easier....
>
> love,
>
> Richard

This was the letter for collaborators to complete their corroboration, addressed to my director of studies, Dai:

> Prof Dai Griffiths
> Chair of the Research Committee
> Institute for Educational Cybernetics
> University of Bolton
> Deane Road
> Bolton
> BL3 5AB
>
> 25 October 2011
>
> Dear Dai,
>
> I have been contacted by Richard Millwood to clarify his contribution in practice to work that we have collaborated on for the purpose of registration for the degree of PhD by Retrospective Practice at the University of Bolton.
>
> I am happy to confirm that his contribution for work I am named in connection with was as indicated in the table below.

Ref	Date	Title	Scope	Contribution	%
P1	1976 to 1980	Teacher of Mathematics and Computer Studies at Scott Lidgett School	Taught Mathematics to mixed ability groups from 11-16 and sixth form A-level groups. Took responsibility in 1978 for Computer Studies and created whole school curriculum analysis in 1979.	Created ‘revelatory’ interactive graphics software for teaching bearings as a game based on NDPCAL research findings. Analysed school curriculum and designed effective presentation.	100

P2	1980 to 1990	Researcher in the Computers in the Curriculum Project at Chelsea College London	Software development, team leadership, development of guidelines informed by research and eventual teacher education and Masters teaching.	Developed many educational programs, guidance documents, course materials and developed analytical models for interface design.	100
P3	1990 to 1997	Senior Lecturer in Ultralab at Anglia Polytechnic University	Teacher educator for BEd, PGCE and Masters level, developer of interactive multimedia and research team leader.	Developing course materials, employing grounded theory to develop teacher profiling tool, developing online Masters programme. Building Ultralab as a developer, technical expert and mentor in the design of interactive multimedia software.	25% (with Prof Stephen Heppell and others)
P4	1979 to 1985	Member of Microcomputers in Computer Education (MICE)	Group of Computer Studies teachers concerned to create interactive software for learning concepts in computing	I developed my own program but also helped critique colleagues designs.	100%
P5	1988	An analysis of a single interaction	First published in 'Design Guide for the Procedure Library' published by the Computers in the Curriculum Project.	I co-authored the design guide and co-created the diagram and analysis published.	50% (with David Riley)
P6	2003	Ultraversity	A new fully online work-focussed degree employing multiple innovations, created by a small team and further developed by a 20 strong team for which I had overarching responsibility. 144 students graduated in 2006.	I co-developed the validation documents and mentored the team.	20% (with Prof Stephen Heppell, Stephen Powell and others)
P7	2009	Analysis of learning - expression and evaluation	A cybernetic inspired model of the learner activity which promotes learning, inspired by Kolb's models, but addressing modalities and technological support.	This is my original analysis, part of multiple keynote presentations at national and international conferences.	100%
P8	2009	Analysis of education - the learner's perspective	A model of learner's decisions to progress in learning which ties in the full educational context.	This is my original analysis, part of multiple keynote presentations at national and international conferences.	100%
P9	2009	Analysis of education – the stakeholders' perspectives	Simple models of key questions faced by teachers, organisational leaders and governments to sustain their educational contexts.	This is my original analysis, part of multiple keynote presentations at national and international conferences.	100%

P10	1986 to 1991	Member of the London Mental Models Group	A multidisciplinary research group led by the late Joan Bliss of King's College London involving staff in science, mathematics and history education, but also in language, cognitive psychology, educational computing, expert systems and artificial intelligence.	I participated and contributed to seminars considering models of learning with technology.	5% (Project lead by the late Prof Joan Bliss)
P11	1987 to 1993	Renaissance Project funded by Apple Computer	A higher education interactive multimedia CD-ROM development project.	I helped design, collate, program and took sole responsibility for technical production of some of the earliest CD-ROMs developed for education.	20% (with Prof Stephen Heppell and others)
P12	1994 to 2000	Learning in the New Millenium Project	Sponsored by Nortel this was a longitudinal project which connected academics, engineers at Nortel and school pupils in an online learning community.	Mentor, PhD supervisor for the lead researcher.	5% (with Prof Stephen Heppell, Carole Chapman and others)
P13	1997	The Online Learning Network	An Institute for Public Policy Research funded project in advance of the University for Industry (UfI). Education professionals from the school, museum, HE, broadcast and private sectors generated dialogue on a selection of issues, and participated in "online experiences" to demystify and learn how use ICT effectively.	Mentor to project leader and contributor to the online community design.	10% (with Prof Stephen Heppell, Leonie Ramondt and others)
P14	2000 to 2003	Talking Heads and Virtual Heads	Projects to develop informal and formal learning for the UK's head teachers.	Mentorship and hands-on practical help to establish project and design interactive multimedia learning resources.	5% (with Prof Stephen Heppell and others)
P15	1996 to 2000	TeacherNet UK	A proposal for a national online community of practice for teachers.	Co-developer of the ideas and design, director of the organisation and designer and developer of web-site.	25% (with Prof Marilyn Leask and others)
P16	1998 to 2000	Étui	Development of an educational toy to support children's learning as part of a European project in the Experimental Schools section of the i3 network (Intelligent Information Interfaces). The device stimulated meta-level learning awareness, problem solving, creativity and collaboration through activities.	Mentorship and development of key concepts of meta-level learning. Data collection in field research and data analysis and reporting.	20% (with Prof Stephen Heppell, Professor Dai Griffiths and others)

P17	2000 to 2005	Summer School	A collaboration with the South East of England Virtual Education Action Zone to establish the capabilities in young people for digital creativity using technology.	Mentorship, organisation and presentation at the Victoria and Albert Museum.	10% (with Prof Stephen Heppell, Matthew Eaves and others)
P18	2002 to 2004	Input BBC	A collaboration between Children's BBC Television and Ultralab to explore the future of kids TV. Computers and digital video cameras were placed in schools, community and learning centres across the North of England to find out what television could be like if children were to make it themselves.	I co-directed the project with TV producer Cathy Derrick and took part in the organisation of workshops, gathering and analysis of data, design of web site and online survey.	25% (with Prof Stephen Heppell, Matthew Eaves, Cathy Derek and others)
P19	2003 to 2006	Ultraversity	An undergraduate degree programme with a personalised programme that enabled students to gain a degree in three years through researching into their current work role. The focus of the degree is on students 'understanding why and knowing how to ' and develops individuals to become articulate, critically reflective problem solvers within their work context.	Initially involved as co-writer of the validation documents, designer of marketing and publicity and developer of key concepts. Ultimately I was responsible for oversight of the project which involved 20 staff.	20% (with Prof Stephen Heppell, Stephen Powell and others)
P20	2007 to 2011	Inter-Disciplinary Inquiry-Based Learning Project	A framework model for undergraduate and postgraduate learning based on the Ultraversity work, but intended to support innovation at the University of Bolton.	Collaborator with two others to develop model further and to collect data, analyse and produce peer-reviewed publications.	20% (with Oleg Liber, Stephen Powell and Mark Johnson)
P21	1992 to 2011	National Archive of Educational Computing	A research and public archive of artefacts, papers, software and media recording the UK history of technology enhanced learning.	Initially collaborator in acquisition and formulation of concept, latterly director and developer of web-site. Direction and development of research methodology, cataloguing, curation and interpretation.	75% (with Prof Stephen Heppell and others)

If you require further information please do not hesitate to get in touch with me.

Yours faithfully,

[SIGNED]