

**The Leverhulme Trust**  
**APPLICATION FORM - Emeritus Fellowship**

Applicant: Dr Meurig Beynon	ID/Ref:
Project Title: Constructivist computing: new modes of learning for science and the humanities	

**Applicant Details**

<b>Submission Date:</b>	N/A
<b>Total Requested:</b>	19,710

**General Details**

<b>Title</b>	Dr	<b>Gender</b>	Male
<b>First Name(s)</b>	Meurig	<b>Date of Birth</b>	26/08/1948
<b>Surname</b>	Beynon		
<b>Honours</b>			

**Contact Details**

<b>Department</b>	Computer Science		
<b>Institution</b>	University of Warwick		
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	Coventry United Kingdom CV4 7AL	<b>Email</b>	wmb@dcs.warwick.ac.uk

**Career Details**

<b>Date of retirement</b>	30/09/2010
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**Employment**

<b>Employment 1</b>	10/1999 To 09/2010
<b>Job Title:</b>	Reader in Computer Science
<b>Employer:</b>	University of Warwick

<b>Employment 2</b>	10/1991 To 09/1999
<b>Job Title:</b>	Senior Lecturer in Computer Science
<b>Employer:</b>	University of Warwick

<b>Employment 3</b>	10/1975 To 09/1991
<b>Job Title:</b>	Lecturer in Computer Science
<b>Employer:</b>	University of Warwick

<b>Employment 4</b>	10/1973 To 09/1975
<b>Job Title:</b>	SRC Postdoctoral Research Fellow (Mathematics)
<b>Employer:</b>	University College, Swansea / University of Warwick

<b>Employment 5</b>	10/1972 To 09/1973
<b>Job Title:</b>	Research Assistant (Mathematics)
<b>Employer:</b>	The Open University

### Degree/Qualifications

<b>Degree 1</b>	10/1966 To 07/1969
<b>Degree/Qualification : Subject</b>	BSc : Mathematics
<b>Institution:</b>	Kings College London

### Doctoral Degrees

<b>Degree 1</b>	10/1969 To 09/1972
<b>Degree/Qualification : Institution</b>	PhD : Kings College London
<b>Title of Thesis:</b>	Geometric Aspects of the Theory of Partially Ordered Systems
<b>Supervisor Name:</b>	Professor Philip J. Higgins

### Research Details

<b>Title of research proposal</b>	Constructivist computing: new modes of learning for science and the humanities
<b>Main/sub field of study</b>	Applied Sciences, Computing, Engineering, Mathematics, Science (various), Education (various), Higher Education, International Education, School Education, Design, Music, Humanities (various), Philosophy & Ethics

### Abstract

Constructivist computing is a new conceptual framework for contemporary applications of computer technology that springs from the *Empirical Modelling* research programme I initiated and have developed over many years. It promotes a perspective on computing-in-the-wild complementing that of classical computer science, regarding the computer as *both* an instrument for concrete sense-making *and* a machine for automating abstract computation. My project will consolidate a large body of existing online publications, lecture notes, workshop materials, tools and models so as to disseminate their radical implications for computing theory and practice, and for the philosophy of modelling in education, science and the humanities.

### Places where you will carry out the proposed research

I shall be based at the University of Warwick, where I am an Emeritus Reader in Computer Science. For expert consultation in documenting work on specific research themes, I shall visit the Centre for Computing in the Humanities KCL [Denard, Bradley] and the Institute of Education London [Noss], the Learning Sciences Research Institute Nottingham [Sharples], the National Centre for Computer Animation Bournemouth [Adzhiev, Pasko, Comninos], the Interaction Design Centre Middlesex [Loomes], the Open University [Nuseibeh, Petre] and Portsmouth University [Addis]. I shall also visit universities in Berlin and Potsdam [Mahr, Petsche], Radboud University Nijmegen [Sarbo], and Vrije Univeriteit Belgium [Aerts].

### Details of your established field of research

Empirical Modelling (EM) is a new perspective on practical computing complementary to traditional computer science. Its emphasis is on *construal* - how meaning is associated with computing artefacts because of the ways in which they are interactively experienced by human interpreters - rather than *programming*. Over 25 years, my research group and our multi-disciplinary collaborators have developed principles and tools for model-building for engineering design, business decision-support, humanities computing, computational science and educational technology. Sponsors include BT, IBM and the BBC, where EM enabled a breakthrough in cross-platform digital broadcasting. EM has strong affinities with William James's "radical empiricism".

### Plans for publishing the results of this research

Dissemination has two aspects:

- acquainting mature and influential researchers, many of whom already have much curiosity about EM and are eager to know more, with the ideas and resources that have been developed so far.

- making teaching resources available so that future generations of students and industrial professionals can learn and exploit the ideas more effectively.

Publication plans include:

- the development of an online book
- the preparation of joint journal publications with expert consultants relating to the key themes, building on new and previous collaborations.
- a symposium in May 2013 bringing together all the interested parties.

## Research and Publications

### Detailed statement of proposed research

My project aims to promote a radically new broader vision for computer science: **constructivist computing**. Towards this end, I shall consolidate and disseminate a large body of resources relating to Empirical Modelling developed by me and my research collaborators over the last 25 years. These include over a hundred refereed papers, some twenty research theses, several practical tools for model-building, hundreds of modelling studies, and associated lecture notes and workshop materials (since 1992, EM has been the subject of a Masters level module in Computer Science at Warwick, two international week-long postgraduate summer schools, over a hundred undergraduate projects, and workshops with schoolchildren both face-to-face and online).

Though much of this material is already online, its highly diverse nature and loose - essentially chronological - organisation presents a challenge for interested potential researchers and teachers. The broad range of research themes represented spans *educational technology, engineering design and geometric modelling, model-building for software engineering, computing for the humanities and "human computing", and philosophical foundations of knowing and modelling*. Because it is centrally concerned with how sense-making is linked with interactive model-making, teaching EM requires intimate familiarity with special-purpose modelling tools we have developed and with a wide range of illustrative models.

I plan to compile an online book on constructivist computing that integrates reading materials with video demonstration resources and well-documented models that can either be exercised directly online or are available for download. The basic structure of the book will be such that a reader with a specialist interest in any particular area of application can access appropriate resources without having to conduct a complex search. Chapter 1 will provide background by way of orientation and motivation, drawing on critiques of computer science, on constructivist thinking and its implications, and on philosophical foundations to be found most notably in the work of William James. Chapter 2 will introduce the principles and tools for EM. The key idea will be that of using the computer to develop sense-making artefacts called 'construals' that reflect patterns of observables, dependencies and agency (ODA) such as are experienced by the model-builder. Chapter 3 will explain how the ODA framework supplies a foundation for universal multi-agent modelling in which the modes of agency, interaction and interpretation are exceptionally rich and fluid. Chapters 1, 2 and 3 will be core material prerequisite to understanding the applications of constructivist computing to be discussed in subsequent chapters. There will be five such chapters, each self-contained in content and devoted to one of the five research themes highlighted above. The concluding chapter of the book will frame a future agenda for constructivist computing with particular reference to ways in which the notion of constructivist computing relates to current trends in computing and potential future applications in society and industry.

I see constructivist computing as a nascent new research field that is closely related but complementary to traditional computer science. Its full exploration is not a task for any individual researcher; it will require input and critiques from specialists in many disciplines. In my book, I do not expect to be able to address the relationship to existing work in each of the five application areas as thoroughly as I would ideally like; I shall focus on the issues most directly relevant to my core theme. Since understanding these relationships is crucial when seeking to attract interest from researchers in adjacent established fields (e.g. such as agent-based modelling), I propose to liaise

with sympathetic experts in each key area. These experts will include former research students, now working in industry, who have themselves developed specialist knowledge of application areas. I shall also recruit my colleague Steve Russ, my chief research collaborator and the author/co-author of many key ideas, to assist me in a primarily editorial role.

In promoting constructivist computing, maintaining the tools for construction and the library of construals is a major challenge. Our principal tool is an open source interpreter conceived in 1987 and since developed extensively by research and project students. This exists in multi-platform download and web-enabled variants. A recently developed alternative tool supports richer observables resembling processes and objects in nature. All three tools serve different roles to be illustrated in my book. For this purpose, I shall select representative pre-existing models, and direct a small team of technically-equipped student assistants in the time-consuming but generally routine task of customisation and documentation. Occasional consultation with the ex-student developers of the key tools will be essential, especially in resolving problems precipitated by changes to software environments beyond our control.

I shall meet my dissemination goals through joint publications with expert consultants on the key themes and through a symposium in spring 2013 that brings together our experienced consultants and potential industrial partners with the younger generation of former EM-research students.

## Major publications

From formalism to experience: a Jamesian perspective on music, computing and consciousness  
Book chapter in Music and Consciousness (ed. David and Eric Clarke), OUP, 2011 [in press]

(with Nicolas Pope) Empirical Modelling as an unconventional approach to software development, Proc. SPLASH 2010 Workshop on Flexible Modeling Tools, Reno/Tahoe Nevada, USA, October 2010

(with Antony Harfield) Constructionism through Construal by Computer, Proceedings Constructionism 2010, The American University of Paris, August 16-20, 2010

(with Daniel Keer, Steve Russ) Computing for construal: an exploratory study in ant navigation  
Procedia Computer Science, Volume 1, Issue 1, May 2010, 2201-2210

(with Antony Harfield and Richard Myers) Web Eden: support for computing as construction? Proceedings of the 9th Koli Calling International Conference on Computing Education Research (ed. Pears and Schulte), November 2010, 47-50

Constructivist Computer Science Education Reconstructed, HEA-ICS ITALICS e-Journal, Volume 8 Issue 2, June 2009, 73-90

(with Steve Russ) Experimenting with Computing, Journal of Applied Logic 6 (2008), 476-489

(with Antony Harfield) Lifelong Learning, Empirical Modelling and the Promises of Constructivism, Journal of Computers, Volume 2, Issue 3, May 2007, 43-55

Computing technology for learning - in need of a radical new conception, Journal of Educational Technology & Society, 10 (1), 94-106, 2007

(with Russell Boyatt and Steve Russ) Rethinking Programming, Proceedings IEEE ITNG 2006, 149-154

Mathematics and Music - Models and Morals. In Conference Proceedings, Bridges London: Mathematical Connections in Art, Music, and Science (eds. Sarhangi and Sharp), Tarquin Books, 2006, 437-444.

(with Steve Russ and Willard McCarty) Human Computing: Modelling with Meaning. Literary and Linguistic Computing 21(2), 2006, 141-157

Towards Technology for Learning in a Developing World. Proc. IEEE 4th International Workshop on Technology for Education in Developing Countries, Iringa, Tanzania, July 2006, 88-92

Radical Empiricism, Empirical Modelling and the nature of knowing. In (ed. Itiel E Dror) Cognitive Technologies and the Pragmatics of Cognition: Special Issue of Pragmatics and Cognition, 13:3, December 2005, 615-646.

(with Chris Roe) Computer support for constructionism in context, Proc. of ICALT'04, Joensuu, Finland, August

- (with Abhir Bhalerao, Chris Roe and Ashley Ward) A computer-based environment for the study of relational query languages, Proc Teaching, Learning and Assessment in Databases W/S, Coventry, UK, July 2003, 104-108
- (with Suwanna Rasmequan and Steve Russ) A New Paradigm for Computer-Based Decision Support. Decision Support Systems, vol 33 (2002) 127-142
- Liberating the Computer Arts, Proc 1st International Workshop on Digital and Academic Liberty of Information, University of Aizu, Japan, March 2001 (25pp)
- (with Jaratsri Rungrattanaubol and Jane Sinclair) Formal Specification from an Observation-Oriented Perspective. Journal of Universal Computer Science, Vol. 6 (4), 407-421, 2000.
- (with Ashley Ward, Soha Maad, Allan Wong, Suwanna Rasmequan, and Steve Russ) The Temposcope: a Computer Instrument for the Idealist Timetabler, Proc 3rd International Conference on the Practice and Theory of Timetabling, Constance, Germany, August 2000, 153-175
- Empirical Modelling and the Foundations of Artificial Intelligence, Computation for Metaphors, Analogy, and Agents, LNAI 1562, Springer, 322-364, 1999
- (with Pi-Hwa Sun) Computer-mediated Communication: a Distributed Empirical Modelling Perspective Proceedings of Cognitive Technology 99, San Francisco, 1999
- Empirical Modelling for Educational Technology, Proc Cognitive Technology '97, IEEE, 54-68, 1997
- (with Valery Adzhiev and Alexander Pasko) Interactive Geometric Modelling based on R-functions, Proc CSG'94: Set-Theoretic Solid Modelling: Techniques and Applications, Winchester, Information Geometers, 1994, 253-272
- (with Valery Adzhiev, Alan Cartwright and Yun Pui Yung) A New Computer-Based Tool for Conceptual Design, Proc Workshop Computer Tools for Conceptual Design, Univ. of Lancaster, 1994, 171-188
- Boolean Function Complexity: a Lattice-Theoretic Perspective. In Boolean Function Complexity, ed. M. S. Paterson, LMS Lecture Notes Series 169, CUP 1992, 35-56
- (with Steve Russ) The Development and Use of Variables in Mathematics and Computer Science The Mathematical Revolution Inspired by Computing, IMA Conf Series 30, 1991, 285-95
- (with Mark Norris, Rodney Orr, Mike Slade) Definitive specification of concurrent systems, Proc UKIT'90, IEE Conference Publications 316, 1990, 52-57
- (with Yun-Pui Yung) Definitive Interfaces as a Visualisation Mechanism, Proc Graphics Interface '90, Canadian Information Processing Soc., 1990, 285-292
- Parallelism in a definitive programming framework, Parallel Computing 89, Advances in Parallel Computing Vol. 2, North-Holland 1990, 425-430
- A definitive programming approach to the implementation of CAD software, in Intelligent CAD Systems II: Implementation Issues, Springer-Verlag 1989, 126-45
- Definitive principles for interactive graphics, Theoretical Foundations of Computer Graphics and CAD, NATO ASI Series F, Vol 40, Springer-Verlag 1988, 1083-1097
- (with John Buckle) On the planar monotone computation of Boolean functions. Theoretical Computer Science 53, 1987, 267-279
- Replaceability and computational equivalence for monotone boolean functions. Acta Informatica 22, 1985, 433-449
- Applications of duality in the theory of finitely-generated lattice-ordered Abelian groups. Can J Math 29 (2) 1977, 243-254

Vector lattices freely generated by distributive lattices.  
Math Proc Camb Phil Soc 81, 1977, 193-200

Duality theorems for finitely-generated vector lattices.  
Proc London Math Soc (3) 31, 1975, 114-128

Combinatorial aspects of piecewise-linear maps.  
Journal London Math Soc (2) 7, 1974, 719-727

### Other matters you wish to bring to the attention of the Committee

- a projected follow-up special issue journal publication based on the proceedings of the symposium and complementary submissions

Experts and collaborators

educational technology Noss, Pratt, Jones, Sharples, Sutinen, Kommers, Nehaniv, Kalas

radical design / geometric modelling Adzhiev, Pasko, Comninos, Kalawsky

modelling for software engineering Mahr, Jackson, Braude, Loomes, Nuseibeh

philosophy of science: exploratory experiment Latour, Petsche, Addis, Aerts, Sarbo, Janack

humanities computing / human computing McCarty, Denard, David Clarke, Tolmie, Petre, Ramsay

Former EM research students

Cartwright [BBC], Care [BT], Maad [TCD], Roe, Heron (Apteco), Harfield, Chan, Ward, Pope

Commercial interests

Dave Catlin [Valiant Technologies], Michael Mainelli [Z-Yen]

### Duration and Timing

<b>Duration of Fellowship (3-24 months)</b>	24
<b>Proposed start date</b>	01/08/2011
<b>Percentage of time to be spent on the project during the Fellowship</b>	50

### Details of other research projects and commitments during the Fellowship

I shall be committed to teaching an MSc/MEng module "Introduction to Empirical Modelling" during the Autumn Term in 2011-2 and 2012-3. I am also planning to be involved in online teaching activities under the auspices of the Warwick International Gateway for Gifted Youth and the International Summer School programme for undergraduates (scheduled to run in July 2012 and July 2013). These teaching activities are in some respects complementary to my proposal.

### Referees

<b>Referee 1</b>	Professor Willard McCarty
<b>Department : Institution</b>	Centre for Computing in the Humanities : King's College London
<b>Position:</b>	Professor of Humanities Computing
<b>Email:</b>	willard.mccarty@kcl.ac.uk

<b>Referee 2</b>	Professor Mike Holcombe
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<b>Department : Institution</b>	Computer Science : Sheffield University
<b>Position:</b>	Professor of Computer Science
<b>Email:</b>	m.holcombe@sheffield.ac.uk

## Previous and Current Applications

### Previous Leverhulme awards or pending applications to the Trust

None.

### Other awards received in the last year related to this research

Funding to attend the scientific workshop on "The Philosophy of the Information and Computing Sciences" at the Lorentz Centre in Leiden in February 2010.

Erasmus funding to contribute to a module on the theme of "Knowing and Computing" organised by Prof Hans-Joachim Petsche in the Institute of Philosophy at the University of Potsdam January 2011.

### Applications you have made or intend to make to other bodies related to this research proposal

I intend to approach other bodies, such as the Royal Society, the EPSRC, the AHRC and the BCS to obtain supplementary funding for the symposium planned for April or May 2013. The future of computer science and its applications in science and the humanities is a topical theme for all of these bodies. We obtained funding for a previous workshop on a related theme ("Thinking Through Computing") from the AHRC under the *ICT Methods Network* scheme in 2007.

### Any active grants that would run concurrently with the proposed period of the Fellowship? If so, how much time will these take up?

None.

### Any support costs to be provided by your institution beyond the formal retirement date

In my capacity as an Emeritus Reader in Computer Science, I have the use of a shared office and other departmental resources (e.g. computer, photocopier and printer access). Appropriate resources of this nature would also be available to support the proposed student summer vacation work. In connection with the preparation of video resources, I shall have access to facilities and advice from staff associated with the University of Warwick *Institute for Advanced Teaching and Learning*.

## Finance

### Research Expenses

	Year 1	Year 2	Total

<p><b>UK travel</b>  London central area short visits (£50 rtn rail fare):</p> <p>Institute of Education, London University (Noss, Pratt, Kent et al)  Centre for Computing in the Humanities, King's College London (Denard et al)</p> <p>Short visit Bournemouth and Portsmouth (£100 rtn rail fare)</p> <p>National Centre for Computer Animation, Bournemouth University (Adzhiev, Pasko and Comminos)  Portsmouth University (Addis)</p> <p>Short visit Middlesex (£50 rtn rail fare)</p> <p>Interaction Design Centre, Middlesex University (Loomes et al)</p> <p>Day Visits (10 in total - petrol costs £400)</p> <p>The Open University, Milton Keynes (Nuseibeh, Petre et al)  Learning Sciences Research Institute, Nottingham University (Sharples, Jones et al)</p>	<p>£300</p>	<p>£300</p>	<p>£600</p>
<p><b>UK subsistence</b>  Accommodation for Central London visits (3 + 3 days) (£400):</p> <p>Institute of Education, London University (Pratt, Kent et al)  Centre for Computing in the Humanities, King's College London (Denard et al)</p> <p>3 day visit to Interaction Design Centre, Middlesex University (Loomes et al) £120</p> <p>Accommodation for South Coast visits (3 + 3 days) (£350):  Bournemouth and Portsmouth</p> <p>National Centre for Computer Animation, Bournemouth University (Adzhiev, Pasko et al)  Portsmouth University (Addis)</p>	<p>£520</p>	<p>£350</p>	<p>£870</p>

<p><b>Overseas travel</b>  Short visits to Berlin and Potsdam (£300 coach, air and rail)</p> <p>Technische Universität, Berlin (Bernd Mahr)  Potsdam Universität (Hans-Joachim Petsche)</p> <p>Short visits to the Netherlands (£300 coach, air, rail)</p> <p>Radboud University, Nijmegen (Janos Sarbo)  University of Twente (Piet Kommers et al)</p> <p>Short visit to Belgium (£200 coach, air, rail)</p> <p>Vrije Universiteit Brussel (Diederik Aerts)</p>	£500	£300	£800
<p><b>Overseas subsistence</b>  Short visits to Berlin and Potsdam (£700 subsistence)</p> <p>Technische Universität, Berlin (Bernd Mahr)  Potsdam Universität (Hans-Joachim Petsche)</p> <p>Short visits to the Netherlands (£700 subsistence)</p> <p>Radboud University, Nijmegen (Janos Sarbo)  University of Twente (Piet Kommers et al)</p> <p>Short visit to Belgium (£400 subsistence)</p> <p>Vrije Universiteit Brussel (Diederik Aerts)</p>	£1,100	£700	£1,800

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<p><b>Research assistance</b>  Student summer vacation work (2 students for 6 weeks in August 2011 and 8 weeks in July-Sept 2012, and 2 other students for 8 weeks in July-Sept 2012 and 2 weeks in July 2013) (£8640)</p> <p>Consultancy payment to key software tool developers (£2400)</p> <p>The EDEN interpreter (Ashley Ward)  The Web-EDEN interpreter (Richard Myers, Antony Harfield)  The Cadence interpreter (Nicolas Pope)</p> <p>Summer vacation students will assist in web resources preparation, model presentation, and routine tool documentation and refinement. Two pairs of assistants will cover the overlapping periods Aug 2011 - Sept 2012 and July 2012 - Sept 2013. Each assistant costs £180 per week.</p> <p>Documenting the software tools underpinning my online book, and refining them for convenient and reliable use, requires essential consultation with their principal developers. These developers will not be students, and I assume 120 hours of consultation at £20 per hour. (Bug fixes may require the expertise of the original developer and take hours to diagnose and resolve.)</p>	£5,520	£5,520	£11,040
<p><b>Secretarial assistance</b>  Secretarial assistance will be needed in organising the 2-day symposium to be held in April or May 2013. We expect to have 20-25 attendees, and will need to communicate with them over travel and accommodation plans prior to the symposium, and to provide administrative support during their visit.</p> <p>We require the equivalent of 1 week of secretarial support in preparation for the symposium, and 2 days for administrative support during the symposium itself. On an salary of £25,000 this equates to £600.</p>	£0	£600	£600

<p><b>Conferences</b>  We shall hold a 2-day workshop on the theme of "Constructivist Computing" in Computer Science at the University of Warwick in April or May 2013. We shall bring together 20-25 invited participants representing our expert advisors and collaborators, former EM research students, and interested people from industry. We shall expect participants to find their own travel costs, but provide accommodation for approximately 20 participants for 2 nights at 100 pounds at a total cost of £4000.</p>	£0	£4,000	£4,000
<b>Total</b>	<b>£7,940</b>	<b>£11,770</b>	<b>£19,710</b>

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