

**Project title:**

Challenging and complementing the "computational thinking" paradigm: liberating computing for construal

**Executive Summary:**

Computational thinking (CT) has a major influence over perceptions of how mathematics advances human knowledge and notions of mind and intelligence. CT focuses on interpreting activity in logical rule-based program-like terms.

We shall disseminate principles and tools ("Empirical Modelling") that challenge and complement the CT culture. EM makes construals rather than programs. Construals serve a personal sense-making function; they enrich the living experience of the person interacting with them.

We shall promote a thesis giving deeper insight into CT and its limitations:

- the significance and power of formal accounts of human activity is best appreciated by making EM construals
- computing technology liberates the making of construals
- undue weight given to CT is redressed by EM's account of computing.

Dissemination will be via summer schools and ongoing collaborative making of construals exploiting web-enabled tools. Teaching resources will be based on extant materials to be refined with collaborators in academia and industry. Participants will be recruited from sympathetic groups in diverse disciplines worldwide. We shall establish a worldwide community of academic and industrial researchers to promote a radically new perspective and curriculum for computing.

**Project Description:**

What are the limits of mathematics in advancing human knowledge? and what have the difficulties of AI taught us about the nature of mind and intelligence? These Big Questions implicitly invoke computing; they are topical primarily because of the impact of computing science and technology on the modern - and especially the developed - world.

"Computational thinking (CT)" is the paradigm best suited to many applications of computing in business, science and education. Under its influence, abstract formal mathematics has acquired unprecedented concrete practical relevance. What limits can be set on the transformative power of CT is unclear. This has encouraged some to place such faith in the CT outlook endorsed by classical computer science and logicist AI that they scorn any alternative conceptualisation of human experience.

Our project will disseminate the findings of a mature and ongoing research programme ("Empirical Modelling"), conceived within computer science, that challenges and complements CT. EM gives integrity and direction to computing practices that go beyond CT and, in the process, deepens our understanding of the Big Questions radically. EM shows how computing can help to express the intuitions behind mathematics that guide human understanding in its applications. EM also supplies a holistic view of mind and intelligence that integrates human and computer activity. Above all, by recognising our human capacity for free and imaginative thinking, creativity and discovery, it counters the tendency in CT to reduce human experience to rational processes.

A credible alternative to CT must offer roots and concepts as intellectually compelling as those supplied by Turing and the rich culture that surrounds programming. EM builds on the philosophical foundation of William James's radical empiricism, giving priority to knowing as rooted in personal experience and not

necessarily subject to classification as objective knowledge. EM principles and tools are directed at making live interactive artefacts that embody patterns of observables, dependencies and agency found in experience. Such artefacts serve as construals: environments for open-ended interaction and exploration admitting many interpretations, resembling the models constructed by experimental scientists making sense of unfamiliar phenomena or by humanities scholars investigating possible meanings and significance in a work of art.

Our dissemination programme will capitalise on existing international links representing a wide range of subject areas. These include (e.g.) contacts made via invited visits to Taiwan and the US and two international postgraduate EM summer schools, participants in workshops hosted by the EM research group and partners in several project proposals. EM is intimately linked not only with science and engineering, but with philosophy and education (e.g. it is a central theme of a philosophy module at Potsdam, and has been deployed to support teaching in Africa). Where traditional computer science views other disciplines as "areas of application for mathematics and AI", EM envisages an integral role for mathematics and AI within a radically new curriculum for computing that bridges science and the humanities.

Two summer schools are the focal point of our dissemination, but as important is initiating and sustaining online activities to attract and retain engagement from researchers in academia and industry worldwide. We have proof-of-concept for our online tools and proposed infrastructure in in-house EM education, activities we have organised for schools, teaching on the Virtual Studies in CS programme in Finland, and work with pupils in Nokia's schools liaison programme. We shall bring our key partners together for two workshops to prepare the summer school programmes and conceive the ongoing online activity. We shall also recruit partners trained in EM to act as consultants and tutors, with whom we shall liaise through visits.

**Project Description Attachment:  
Strategic Promise:**

Our project champions a new conception of computing that embraces both scientific and humanistic perspectives. Through the radical step of rooting computing activity in what lies before and beyond language, it answers Emil Post's call - reacting to Godel's negative findings regarding formal logic - for "a return to meaning and truth".

Our project shows how to exploit computer technology so as to integrate learning with construction. It promises a fresh vision for constructivism with major implications for intelligible, flexible and collaborative crafting of meanings in applications such as education, decision-support, software development and computational science.

Our project stimulates a new culture of thinking that favours sense-making in and through experiencing as well as sense-making through rationalisation post-experience. This provides an antidote to the often problematic rationalisation of the developed world, and a disposition much better suited to the developing world.

**Capacity for Success:**

Beynon founded and leads the EM project. He is also a mathematician (cf. the Baker-Beynon duality) who has contributed to theoretical computer science. Russ is a leading international expert on the history and philosophy of mathematics. Over 20 years, they have supervised research into the implications of EM for AI, systems development, engineering design, educational technology, decision support and humanities computing that has led to over 100 refereed publications, over 20 research theses and hundreds of models. These resources have sustained an annual masters level module with examined and practical components over 15 years. EM has attracted industrial support (e.g. British Telecom, IBM and the BBC) and

international interest (e.g. in invited workshops on education and business in Taiwan and Germany). Other contributors will be collaborators from universities and companies including people trained in EM by us who are eager to contribute their time to make the project a success.

### **Expected Outputs:**

- Two 5-day summer schools, in 2011 & 2012, to teach EM to about 25 academics, research students and researchers from industry
- Online materials for the summer schools including lecture notes, videos, podcasts & model construals
- An infrastructure for ongoing asynchronous collaborative model development exploiting our web-enabled interpreter
- Accessible online activities to convey the basic concepts and technical skills of EM, designed for advertisement and training
- Two 2-day workshops early in 2011 & 2012 to plan the summer schools and identify key issues to be addressed
- Journal papers to include:
  - a discussion of mathematics, mind and intelligence in relation to William James's radical empiricism
  - a historical and philosophical appraisal of mathematics informed and illustrated by appropriate studies in EM
  - a comparison of models of mind and intelligence as in AI and as in EM
  - an extended review of a new vision for a computing curriculum based on EM.

### **Expected Outcomes:**

- A wider and deeper appreciation of the role of direct experience in mathematics, mind and intelligence, and of why we should distrust language and reasoning as a foundation for addressing the Big Questions
- Consolidation of a cross-disciplinary community of at least 50 academics worldwide who share our concern about the impact and limitations of "computational thinking", and the unwelcome implications this has for society if unchallenged
- Educating at least 20 younger researchers in academia and industry to appreciate computing in broader more mature terms: being familiar with the concept of construal, recognising its importance in relation to sense-making and communicating making use of collaborative environments in which they manipulate construals as a communication medium complementary to and in some contexts preferable to text
- EM being taught and practised at at least 5 institutions outside Warwick, each contributing to a radically new curriculum for computing

### **Currency:**

GBP

### **Request Amount:**

162398

### **Total Project Amount:**

225800

### **Additional Funding from Other Sources:**

The difference between the Total Project Amount and the amount requested from the Foundation is 63402 GB pounds. This cost will be met by the University of Warwick. This will cover computer support for the summer schools and workshops, website development for publicising the events, computer facilities for delegates etc. It will also cover the extra University overheads not funded by the Foundation.

Our project complements ongoing EM-related educational projects aimed at learners other than traditional university students for which funding is being sought from the European Union and from the Leverhulme Trust.

**Proposed Project Start Date:**

1/1/2011

**Proposed Project End Date:**

12/31/2012

**Relation to Sir John Templeton's Donor Intent:**

The affinities between EM and William James's radical empiricism are striking and deep. In making construals, meanings are enlisted through interacting and exploring, not prescribed as in traditional programming. Associations "given in experience" take priority over interpretations specified in a formal language. Taking a pragmatic stance open even to religious experience, James writes: "how these experiences are made, we cannot begin to understand"; he likewise refuses to give any absolute authority to our attempts to identify causal relationships. These qualities are reflected in the personal, provisional, pragmatic nature of EM construals. The interplay between intuitive and rational perceptions of experience in EM can be likened to the theologian Martin Buber's exegesis of the I-Thou and I-It relations. Openness to the possibility of discovery and creative insight is of the essence in EM, in keeping with Sir John's concern for humility, acknowledgment of ignorance, and optimism.

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**History with the Foundation:**

We learnt about the relevant Templeton Foundation's funding initiative from Willard McCarty, who publishes the online Humanist newsletter. We have not received funding from the Foundation previously, attended any Foundation-sponsored event or discussed our proposed project with anyone at the Foundation.

Organization Name: University of Warwick

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