55. Tackling Integrative Applied Research: Lessons from the management of innovation

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> Far better an approximate answer to the right question, which is often vague, than an exact answer to the wrong question, which can always be made precise.
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> — John Tukey
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> Even the dogs may eat the crumbs which fall from the rich man's table; and in these days, when the rich in knowledge eat such specialised food at such separate tables, only the dogs have a chance of a balanced diet.
>
> — Sir Geoffrey Vickers, Introduction to *The Art of Judgment*

I have spent nearly 25 years grappling with the complexities of the strategic management of applied research. Most of my experience is with CSIRO—a large, diverse applied research and technology-transfer organisation[2]—where I have worked on increasing the effectiveness of the research effort at both whole-of-CSIRO and research division levels. This has been through strategic planning, investment and assessment, as well as work on the factors necessary for excellence in applied research.

I agree wholeheartedly with the importance, and urgency, of the problem domain of Gabriele's book: the use of integrative applied research to tackle complex real-world problems. Integrative applied research has many of the same characteristics as innovation,[3] and the practice of integrative applied research can learn from the practice of innovation. This is the perspective I bring to this commentary.

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1 Ian Elsum was invited as a 'member of the research leadership team at CSIRO and as someone who has a longstanding interest in integration to tackle complex real-world problems. Your observations on whether the ideas in the book are workable in an organisation such as yours will be very pertinent.'

2 The Commonwealth Scientific and Industrial Research Organisation (CSIRO) was founded in 1926 as a scientific research institute for Australia. It has 6500 staff and an annual budget of $1.5 billion. The organisation emphasises integration of its broad range of scientific and technological areas to address problems across a very broad range of application areas; see <www.csiro.au> (accessed 15 February 2012).

3 Innovation has two components: creation of new knowledge (invention) and exploitation of the new knowledge—that is, putting it to use to create value. Both components are essential.

An overarching challenge of integrative applied research is that it is an inextricable combination of a quest for fundamental understanding and practical use of this understanding. This is Pasteur's quadrant.[4] Managing the tension between the traditional approach to the quest for fundamental understanding (reductionism and increasingly specialised disciplines) and the needs of complex real-world problems (integration of knowledge from multiple areas at a system level) is critical to success.

My starting point is to examine some of the characteristics of integrative applied research and complex real-world problems as these characteristics determine the approach needed for success.

Applied Research

Applied research is fascinating, complex and hard because it is a system problem in which technical factors and factors to do with adoption and use are inextricably linked. As adoption of a technical solution and its use are an integral part of the problem, human, organisational and societal factors impinging upon adoption and use must be an integral part of the research from the beginning of an applied research project.

It is important in applied research to differentiate between adoption and use. Adoption—the willingness and ability to take research results and convert them into something that is useable more broadly—and use by others apart from the adopter must be considered separately as they are distinct processes: the factors causing a person or organisation to adopt research results and incorporate them into an artefact, service or advice will differ in many important ways from those factors pertinent to a person or organisation deciding to use the artefact, service or advice.

Consider, for example, research resulting in a new measuring instrument. The adopter of the research will be an instrument manufacturer; the users will be those organisations that might benefit from utilising the instrument in their operations. Very different sets of factors influence the decisions to manufacture the instrument and to buy it. Another example is public policy and programs where the adopting organisation might be a government agency that will develop policy and programs based on the research results, while the users will be the sections of society that are targeted through the programs.

The need to understand this 'external' (to the research organisation) context for adoption and use can be difficult for many researchers—it is rarely covered

4 Stokes (1997).

in research training in universities—and the incorporation of this perspective into research programs has been a major part of CSIRO's journey as an applied research organisation since the late 1980s.

Applied research involves searching for a workable solution to a fixed real-world problem. The fixed nature of the problem is important: the real world cannot be changed to make the problem more tractable, although the problem can be reframed. 'Workable' because a solution involves a blend of technical factors and factors to do with adoption and use, none of which may be optimum within its particular domain.

What is important for effectiveness in applied research is what works in the particular circumstances (time, place, stakeholders, and so on). Time constraints are also often very important—the first workable solution found is often the one that is used rather than continuing to search for the (probably non-existent) 'perfect' solution. This acceptance of 'less than perfect' can be difficult for many researchers. It has definitely been a difficult cultural challenge in parts of CSIRO as they shifted from pure to applied research.

Acceptance of less than a technically perfect solution is part of the cultural difference between pure and applied research: excellence in applied research is measured by the contribution research makes to enabling a solution to be adopted and used. This can involve significant advances in scientific understanding, but not always; it may, for example, rely more upon insightful integration of existing knowledge. Consequently, the stress that Gabriele places upon accepting the inevitability of imperfection is important for the development of integrative applied research.

The system aspects of applied research become much more complicated, exhibiting many elements of 'wickedness'[5] for the complex real-world problems that are the focus of Gabriele's book. The development of the CSIRO National Research Flagship Program,[6] which is targeted at complex real-world problems, illustrates the challenges inherent in such research.[7]

The challenges of applied research underlie much of what Gabriele covers in this book.

5 Wicked problem: Wikipedia <http://en.wikipedia.org/wiki/Wicked_problem> (accessed 15 February 2012).

6 <http://www.csiro.au/partnerships/NRF.html> (accessed 15 February 2012).

7 See the commentary by O'Connell et al. (Chapter 37).

Uncertainty—Unknowns

Gabriele rightly places strong emphasis on the importance of explicitly dealing with unknowns. Accepted management practices, in business, government and society generally, assume that the ratio of unknowns to knowns is low. There are a number of domains, which include radical or breakthrough innovation[8] and complex social and environmental problems, where this assumption is not true. Development of widely accepted management practices for these domains is a major research challenge, which must be a high priority for integrative applied research.

A corollary of a high ratio of unknowns to knowns is a high level of uncertainty. Most people are not comfortable with a high level of uncertainty and avoid situations in which it is present. The Ellsberg paradox—people so strongly prefer definite information over ambiguity that they make choices consistent neither with the laws of probability nor with themselves—is one manifestation of this aversion to uncertain or ambiguous choices.[9]

High levels of uncertainty or ambiguity are very often equated with high levels of risk. Uncertainty is *not* the same as risk. Risk is best understood as describing a known probability of an event. Uncertainty refers to the absence of sufficient information to predict probabilities of occurrence or results. The ability to describe risk implies some prior experience. If a research team is attempting to overcome a challenge that is truly novel, it may more properly be said to be facing uncertainty rather than risk. The distinction between risk and uncertainty is critical because managing risk is very different from managing uncertainty and the inappropriate use of a risk-management framework can doom a project to failure.

Frameworks for managing when there is a high ratio of unknowns to knowns must

- be loose, as adaptability and flexibility are needed because of high uncertainty
- be learning based
- utilise a decision-making style appropriate for high levels of uncertainty.

In applied research, a learning-based approach will typically include iteration between the technical and adoption/use domains—'probe and learn', for example.[10]

8 Leifer et al. (2000).
9 Ellsberg (1961).
10 Lynn et al. (1996).

Intuition in decision making is not generally regarded favourably; however, it is often the only way to handle high complexity and uncertainty—many unknowables and variables—as it enables integration of multiple factors for which there are few hard data.

> There are too many unknowables, variables…Ultimately, one must use intuition, a complex feeling, calibrated by experience…It's a judgement about people, commitment and probabilities…You dare not use milestones too rigidly.[11]

Improving the effectiveness of decision making when there are many unknowns and uncertainty is high is a critical area for integrative applied research and is a high research priority.

Complexity and Integration

Just as the whole is more than the sum of its parts, solving a complex problem is more difficult than solving its sub-problems. One common strategy to address a complex problem is to divide it into manageable parts (that is, sub-problems). This can introduce a major danger as making a sub-problem tractable can introduce change and making all sub-problems tractable can introduce a lot of change. Solving the sub-problems can result in them diverging in the pursuit of research that can be done successfully, and reintegration can grow increasingly difficult. The larger a scientific collaboration and the greater the number of sub-problems, the more difficult integration becomes. Penders and colleagues[12] provide an example of this in a large-scale research program.

Development of strategies for modularising a complex problem so that work on sub-problems can be reintegrated into the whole without distortion will need to be a high priority for integrative applied research.

Diversity

Diversity is important in solving hard problems because of the different perspectives and heuristics brought to bear on the problem.[13] Jeppesen and Lakhani's work illustrates this through an analysis of the results of 166 science

11 Quinn (1985).
12 Penders et al. (2009).
13 See, for example, Fleming (2007); Jeppesen and Lakhani (2010).

challenges involving more than 12 000 scientists. They found that providing a winning solution was positively related to increasing distance between the solver's field of technical expertise and the focal field of the problem.

Diversity is one aspect of 'difference' that must be highlighted because of its importance for integrative applied research. Research teams which encompass significant diversity must be led and managed differently from less diverse teams.[14] This is one important area for advancing the practice of integrative applied research.

Integrative Applied Research: How? Why a discipline?

How you innovate determines what you innovate; for example, management frameworks for incremental and radical innovation are very different and if an inappropriate framework is used then failure will follow—the desired innovation will not eventuate.[15] Integrative applied research is the same: 'how' will determine 'what'. In this situation the lack of widely agreed management frameworks, which also applies to radical innovation, is a significant issue for the field.

Two aspects of 'how' need emphasis. The first is that research on complex real-world problems is a complex social process, yet the great majority of descriptions of 'how' neglect the people and social dimension. Values are part of this; however, the issue is much broader than values.

The second aspect requiring emphasis is the inherent 'messiness' of the process. This is similar to radical innovation, which has been described as unpredictable, sporadic, nonlinear, stochastic (key players change, priorities change, exogenous events are critical) and context dependent (history, experience, culture, personalities and informal relations all matter).[16] This can be a difficult environment in which to work, particularly in the public sphere of many social and environmental problems. One particular difficulty is people's desire to impose order on an inherently chaotic process[17]—to construct and try to adhere to a structured plan with predetermined milestones, for example.

14 Post et al. (2009).
15 O'Connor et al. (2008).
16 Leifer et al. (2000).
17 Cheng and Van de Ven (1996).

Success in integrative applied research will require solutions to these issues (among others). As Gabriele points out in this book, effort to address the 'how' of integrative applied research is fragmented. So, a vital early step is to foster communities of practice where learning can be shared.

So, how should communities of practice be fostered? In this book Gabriele is advocating the creation of a new discipline (Integration and Implementation Sciences or I2S). The history of the development of disciplines, especially their increasing specialisation and self-referential character, makes me very wary of this path because an external orientation—the 'know–do' link, especially connectivity and iteration between technical disciplines and adoption and use—is fundamental to success in this field. Gabriele acknowledges this danger in the closing section of the book (Chapter 34):

> [T]he danger that I2S becomes self-referential rather than engaged. What I refer to here is the risk that I2S specialists will research and write for each other on ever more arcane aspects of the I2S discipline rather than being part of integrative applied research teams addressing complex real-world problems.

If a new discipline is not the best path forward then what action should be taken?

Sharing knowledge and learning is key to advancing the practice of integrative applied research. There are many ways in which this can be done without creating a discipline. For example, bodies of knowledge can be assembled by practitioners[18] and knowledge shared and extended through conferences, workshops and 'seed' research projects.[19] These forums and mechanisms run across existing disciplines.

Mechanisms running across disciplines can be multiple disciplines coalescing either around a real-world problem or around shared interest in methods, tools, techniques, and so on. Both need to be actively fostered—for example, Flagships and Transformational Capability Platforms respectively in CSIRO. This is a challenge because they cut across organisational structures that are usually discipline based (universities) or application-area based, such as the food-processing industry (applied research institutes).

Despite—maybe because of—these organisational barriers, institutions devoted to research and learning, such as universities, research institutes and research funders, have a responsibility to establish and maintain such mechanisms. They

18 For an example in new product development, see <http://www.pdma.org/knowledge_get.cfm> (accessed 15 February 2012).

19 CSIRO's Transformational Capability Platforms is one example; <http://www.csiro.au/files/files/pmva.pdf> (accessed 15 February 2012).

must recognise and reward integrative applied research and foster communities of practice and other networks of practitioners. Universities have a particular responsibility because students, both graduate and undergraduate, must experience learning across disciplines as well as within the specialisations of traditional disciplines.

Conclusion

There can be no doubt about the importance, and research challenges, of complex real-world problems. Strategies that have been effective for building our knowledge base over the past couple of centuries—reductionism and increasing the specialisation of disciplines—are not sufficient for tackling these kinds of problems. There is an urgent need to devise new approaches. Integrative applied research, as described in Gabriele's book, encompasses most of the elements needed for an effective new approach. The challenge for researchers, research institutions and research funders is to foster a community of reflective practitioners of this new approach. The initial step should be support for organisational centres and networks and recognition and reward for researchers who contribute to the advancement of integrative applied research.

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References

Cheng, Y. and Van de Ven, A. H. (1996). 'Learning the innovation journey: order out of chaos?'. *Organization Science*, 7 (6): 593–614.

Ellsberg, D. (1961). 'Risk, ambiguity, and the savage axioms'. *Quarterly Journal of Economics*, 75 (4): 643–69.

Fleming, L. (2007). 'Breakthroughs and the ''long tail'' of innovation'. *MIT Sloan Management Review*, 49 (1): 69–74.

Jeppesen, L. B. and Lakhani, K. R. (2010). 'Marginality and problem-solving effectiveness in broadcast search'. *Organization Science*, 21 (5): 1016–33.

Leifer, R., McDermott, C. M., O'Connor, G. C., Peters, L. S., Rice, M. P. and Veryzer, R. W. (2000). *Radical Innovation: How mature companies can outsmart upstarts*. Boston, MA: Harvard Business School Press.

Lynn, G. S., Morone, J. G. and Paulson, A. S. (1996). 'Marketing and discontinuous innovation: the probe and learn process'. *California Management Review*, 38 (3): 8–37.

O'Connor, G. C., Leifer, R., Paulson, A. S. and Peters, L. S. (2008). *Grabbing Lightning: Building a capability for breakthrough innovation*. San Francisco, CA: Jossey-Bass/Wiley.

Penders, B., Vos, R. and Horstman, K. (2009). 'Side effects of problem-solving strategies in large-scale nutrition science: towards a diversification of health'. *British Journal of Nutrition*, 102: 1400–3.

Post, C., De Lia, E., DiTomaso, N., Tirpak, T. M. and Borwankar, R. (2009). 'Capitalizing on thought diversity for innovation research'. *Technology Management*, 52 (6): 14–25.

Quinn, J. B. (1985). 'Managing innovation: controlled chaos'. *Harvard Business Review*, 63 (3): 73–84.

Stokes, D. E. (1997). *Pasteur's Quadrant: Basic science and technological innovation*. Washington, DC: Brookings Institution Press.

Brief Biography

Ian Elsum is a Visiting Fellow in the Research School of Management at The Australian National University where he undertakes research on the management of innovation. He was, until recently, Principal Adviser in the Science Strategy and Investment Group of Australia's CSIRO. He is active within the Industrial Research Institute where he has co-chaired Research-on-Research investigations of radical innovation, management of high-uncertainty research and development and the challenges of business model innovation. He has 24 years of experience in the strategic management of applied research, with an emphasis on increasing research effectiveness through strategic planning, investment and assessment as well as work on the factors necessary for excellence in applied research. Ian has been a member of a number of boards and management and advisory committees and is currently chairing the Science Advisory Panel of the Institute of Environmental Science and Research. He has also been a regular participant in forums for the development of industry and innovation policy.

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