1. The Challenge and a New Approach

The question that motivates this book is: '*How can academic research enhance its contributions to addressing widespread poverty, global climate change, organised crime, escalating healthcare costs or the myriad other major problems facing human societies?*' I analyse the solution that has been most widely advocated—namely bringing together relevant disciplines through interdisciplinary teamwork. Indeed the 2004 US National Academies report *Facilitating Interdisciplinary Research*[1] declared that:

> Interdisciplinary thinking is rapidly becoming an integral feature of research as a result of four powerful 'drivers': the inherent complexity of nature and society, the desire to explore problems and questions that are not confined to a single discipline, the need to solve societal problems, and the power of new technologies.

The intent of such interdisciplinary investigations is to maintain the benefits of discipline-based research, while overcoming the limitations. In other words, it is to preserve each discipline's ability to contribute detailed (and sometimes groundbreaking) understanding of specific issues,[2] while moving beyond the restricted scope of individual disciplines, which can go just so far because each covers only some aspects of a complex problem.

I argue that, despite its promise and many excellent individual examples, most interdisciplinary research remains at the academic margins, largely because understanding about such investigations is fragmented. This results from failure to capture the wealth of available experience in a way that allows it to be transmitted and built on. Instead, relevant insights languish undocumented in people's heads or scattered in the published and grey literatures. As a consequence there is no substantial, well-established, internationally accepted methodology. There are no standard procedures for deciding, for example, which disciplines to include, what each discipline will contribute or how the different findings will be melded together. In the absence of comprehensive guidance, newcomers to this type of research still largely rely on intuition to invent for themselves a way to deal with the challenges of interdisciplinary partnership.

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1 Committee on Facilitating Interdisciplinary Research et al. (2004, p. 40).

2 Howard Gardner (2006, p. 138), for example, avers that disciplines 'represent the most advanced and best ways to think about issues consequential to human beings'.

This book addresses that absence. I put forward a proposal for improving the methodological soundness of interdisciplinary research tackling complex social and environmental problems to allow this style of investigation to deliver more fully on its potential and to become firmly embedded in the research mainstream.

Of course, there have been attempts to standardise research that brings together different disciplinary insights; several are presented below and this book builds on their contributions. But my frustration is that they have lacked the necessary scale and traction, which is not surprising for pioneering efforts. This book is based on the premise that there is now enough useful experience and conceptual development to both warrant and permit rethinking what is meant by interdisciplinary research on major real-world problems and how to conduct it most effectively.

Previous groundbreaking work has been both theory and practice based. Small (mostly) groups of researchers have been building theories of interdisciplinarity[3] or of related approaches that include those variously referred to as multidisciplinarity, transdisciplinarity,[4] post-normal science,[5] systemic intervention,[6] integrated assessment,[7] sustainability science,[8] team science,[9] mode 2[10] and action research.[11,12] There tends to be little interaction among these groups, especially for comparative analyses and sharing of insights.

The practice-based advances stem from the work of many research teams. They tend to use 'interdisciplinary' and these other labels to describe their investigations, but employ the terms loosely rather than adhering to precise definitions developed by the theoreticians. Each team usually studies a succession of related problems, generally in one area such as environment or population health. Individual teams have often developed (and sometimes documented) one or more relevant concepts and methods, which they seek to apply to the problems they research. On the whole, there is little cross-fertilisation of the processes of interdisciplinarity between these groups and the teams tend to be isolated from each other. Even teams working in the same broad area (such as environmental problems) are generally not in the habit of sharing methodological

3 Frodeman et al. (2010); Klein (1990); Newell (1998); Repko (2008).
4 Bergman et al. (2010); Hirsch Hadorn et al. (2008); Pohl and Hirsch Hadorn (2007b); Scholz, R. W. (2011).
5 Funtowicz and Ravetz (1993).
6 Midgley (2000).
7 Van Asselt et al. (2001).
8 Clark (2007).
9 Falk-Krzesinski et al. (2011); Stokols et al. (2008).
10 Gibbons et al. (1994).
11 Reason and Bradbury (2001).
12 An anonymous reviewer and some of the commentators pointed out that management sciences, operations research, and complex systems science should also be added to these groups.

insights, and interactions are even rarer between groups investigating different topics, so researchers working on environmental problems hardly ever look for new theory or methods from those studying health issues, for instance.

There are also few connections between the theoreticians and the practitioners. Theoretical developments mostly have not benefited from the extensive range of practical insights. Further, many of the practitioners reinvent conceptual bases for their studies. My observation is that instead of progress built on fertile debate, there are growing pockets of dogma. Prescriptions include such dictums as

- ensuring that all research partners have equal status in order to neutralise power differences
- requiring close working relationships between researchers and those in a position to implement findings
- insisting on a common language and problem definition before starting any investigation.

But such instructions are only suitable in some circumstances.

The argument underpinning this book is that the development of interdisciplinary research on complex real-world problems is held back by the combination of fragmentation, unorganised diversity and dogma. The book therefore sets out to provide a framework that

- builds on the theoretical developments and relevant research experience in interdisciplinarity, multidisciplinarity, transdisciplinarity, post-normal science, systemic intervention, integrated assessment, sustainability science, team science, mode 2, action research and other initiatives
- enables substantial, widespread exchange of ideas and methods
- can be used to collect and evaluate the methodologies.

I begin by developing four arguments.

1. That a specific focus is required, especially since terms like interdisciplinarity have multiple meanings. This book subsequently concentrates on the type of research foreshadowed so far—namely research that involves experts from multiple, diverse disciplines working together on a complex real-world problem.
2. That there is no one 'best' way to conduct such research, but instead there are multiple options, each with advantages and disadvantages. Together they constitute a research style, which I call integrative applied research.

3. That a new discipline—Integration and Implementation Sciences (I2S)—provides an effective way of documenting and transmitting concepts and methods that underpin integrative applied research.

4. That there are thousands of research projects that can provide relevant material, especially concepts, methods and case examples, some on a small scale, some substantial. Because the pertinent material is scattered and often undocumented, compilation is resource intensive, making the natural evolution of I2S likely to take decades. Given that the complex problems facing society require urgent attention, the process could and should be accelerated through a new 'Big Science'-type project. By this I mean a project of the scale and dynamism of the Human Genome Project[13] or the Manhattan Project, which built the atomic bomb.[14] I refer to this as the I2S Development Drive.

In Chapter 2, I make the case that one of the most significant lessons to be learnt from the efforts that have gone into developing interdisciplinarity and related approaches[15] is that integrative applied research is about more than bringing together experts from multiple disciplines, and actually covers three domains

1. synthesising not only disciplinary but also stakeholder knowledge—in other words, pulling together what is known about the problem from both academic research and practical experience

2. understanding and managing diverse unknowns or, to put it another way, appreciating that everything about a complex problem cannot be known and that remaining unknowns must be taken into account in decision making and action

3. providing integrated research support for policy and practice change—that is, supplying policy makers and practitioners with a better understanding of the problem (both what is known and what is not known) in a way that supports them in making decisions and taking action.

I proceed further in Chapter 2 to present a specific framework for fleshing out these three domains, which is the core of I2S and which provides the focus for most of the rest of the book. I foreshadow how populating the framework is the basis for the 'Big Science'-type I2S Development Drive and a significant task for the future. The key purpose of the book is to make the case for I2S as a new discipline by describing its basic structure, and to kick-start a discussion about these ideas. That is the rationale for the last section of the book, which

13 Lambright (2002).

14 Rhodes (1986).

15 From now on I will mostly use this or similar terms to refer to interdisciplinarity, multidisciplinarity, transdisciplinarity, post-normal science, systemic intervention, integrated assessment, sustainability science, team science, mode 2, action research and similar initiatives—both the theoretical and the practical research.

comprises commissioned commentaries from colleagues who have been conducting 'interdisciplinary' research on complex real-world problems or who have leadership roles in research organisations which are keen to contribute more effectively to understanding and responding to society's major challenges.

Let us now return to the four opening arguments

- taking a specific focus
- defining a new research style
- developing a disciplinary underpinning
- responding to the scale and urgency of the task.

Taking a Specific Focus: Looking at one type of interdisciplinarity

One reason existing approaches have difficulty in achieving traction in the research mainstream is that the terms used to describe them have a range of meanings.[16] Let us look at the commonly used term 'interdisciplinarity', which can refer to

- research at the intersection of two disciplines, such as biology and chemistry or psychology and mathematics, which can spawn new disciplines (biochemistry and mathematical psychology, in the two cases given here); this can be large or small-scale and undertaken by individuals or teams
- research across the boundaries of several closely related disciplines like sociology, anthropology and psychology, which involves extensive 'borrowing'[17] of concepts and methods; this can also be large or small-scale and undertaken by individuals or teams
- fields and 'disciplines', like women's studies, population health, criminology and media studies, which draw on a range of disciplinary inputs; within any of these, different disciplines may work together closely or operate in parallel
- research on phenomena that occur across different disciplines, like patterning or hierarchy—for example, patterns occur in many aspects of the natural world and in social systems, from chemical structures at the microscopic level, arrays of stars, planets and other objects in the astronomical world to the movements of fish and birds, friendship networks and traffic flows[18]

16 I have recently developed this argument more fully in Bammer (2012).

17 Discussed in Klein (1990).

18 For example, see the topics at the following symposium: <http://www.radcliffe.edu/events/calendar_2010patterning.aspx> (accessed 2 December 2011).

- research that involves experts from various disciplines and stakeholders from relevant practice areas working on a common problem, such as cybercrime, obesity or erosion.[19]

While all are important, this book concentrates only on the last—namely research that involves experts from multiple disciplines and stakeholders investigating a common problem. The emphasis here is on complex real-world social and environmental problems.

My aim is, therefore, to focus on only one of the kinds of research that are covered by the term 'interdisciplinary' and to put the others aside. The intention is to allow a significant type of research to be recognised, given prominence and further developed.

Defining a New Research Style: Integrative applied research

One consequence of taking a specific focus is that it quickly becomes evident that there is no agreed precise, overarching term that describes *only* investigations involving several disciplinary experts and stakeholders investigating a shared problem. As I have foreshadowed, and will describe in more detail in Chapter 2, the research I am interested in also aims to deal more comprehensively with all the different kinds of remaining unknowns and combines an overview of unknowns along with appreciation of what is known about the problem to support policy and practice change.

As well as being referred to as interdisciplinary, such studies are commonly described by the names multidisciplinary, transdisciplinary and cross-disciplinary. But, as with interdisciplinary, these additional expressions have other meanings.[20] These multiple meanings get in the way of thinking clearly about the research of interest here. Furthermore, the type of research I am describing does not fully overlap with post-normal science, systemic intervention and the other related approaches, although useful concepts and methods can be drawn from them.

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19 It is noteworthy that the Committee on Facilitating Interdisciplinary Research et al. (2004) covered all these approaches to interdisciplinarity except research on phenomena that occur in different disciplines, like patterning or hierarchy.

20 For example, multidisciplinarity and transdisciplinarity are also terms used to describe specific ways of conducting research. Put simply, in multidisciplinary research, each discipline defines and addresses the problem in its conventional way, following which the different disciplinary insights are presented side by side. In transdisciplinary research, disciplinary experts commence the research by actively working together (often with stakeholders and policy makers) to generate a shared understanding and way of tackling the problem, which then guide the investigation and the implementation of its findings.

I therefore argue for a new name that

a) refers only to research involving experts from several disciplines plus stakeholders working on a common complex real-world problem in a way that not only brings together their insights but also deals comprehensively with unknowns, all in order to support policy and practice change
b) is an overarching term that can accommodate a range of options for undertaking such research—for example, it can house various ways of combining disciplinary and stakeholder insights.

I propose 'integrative applied research'.[21]

The point about integrative applied research encompassing a range of methodological options is significant. It opens up the possibility of thinking about integrative applied research as a research style, analogous to quantitative research, empirical research, experimental research and theoretical research. Such a research style can be used to address many types of complex real-world problems—in other words, social problems like organised crime, environmental problems such as global climate change and healthcare problems including escalating costs.

In addition, it orients thinking to a search for more options rather than a hunt for a single 'best' methodology. Said another way, it recognises that different research problems and circumstances require different approaches. Further, each option will have particular advantages and disadvantages. For example, as I described earlier, it is often thought that a team of experts from different disciplines should develop a shared problem definition before commencing their investigation. But there are times when it is most appropriate for each discipline to characterise the problem as it sees fit, rather than compromising on an agreed joint definition. The advantage of starting from a common problem statement is that everyone is working to the same end, but the disadvantage is that achieving such agreement is time consuming and may reduce flexibility for considering new aspects of the problem that become evident as the research progresses. In the alternative, where each discipline works independently, the up-front 'transaction cost'[22] is avoided and flexibility is more likely to be maintained, but the disadvantage is that it may be hard to combine the different disciplinary perspectives.

The point here is not to find a prescription for undertaking integrative applied research, but to recognise and support multiple approaches.

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21 Although applied research is often thought of as leading to the development of some technological innovation, I use it in a broader meaning to refer to research that can also lead to change in government or other policy and in various practices, such as the way services are delivered or technologies are embraced.

22 The transaction cost is the time a team needs to devote to the processes required to successfully work together. If, for example, a team wants to develop a shared understanding and approach to the problem, it needs to be prepared to devote considerable time to understanding how each discipline sees the problem, what methods it can bring to bear and how terms used by one discipline can have different meanings in another.

Developing a Disciplinary Underpinning: Integration and Implementation Sciences (I2S)

In the same way that the discipline of statistics supports different forms of quantitative research, it can be argued that integrative applied research also needs to be underpinned by a discipline. I propose that it is called Integration and Implementation Sciences or I2S.[23] The advantages that such a discipline confers are briefly discussed here. Considerable work is required to develop the discipline and this is explored in subsequent chapters.

A central function of I2S is to bring concepts[24] and methods relevant to undertaking integrative applied research into sharper relief and to allow them to be assessed and built on. I2S captures the considerable effort that various research teams have put into, for example, developing theory about problem definition, and techniques for bringing together different disciplinary insights and stakeholder perspectives.[25]

As well as supplying an effective way to collect and assess relevant concepts and methods, a discipline also provides a way to transmit them between research groups tackling major real-world challenges, even if they are working in very different areas. Statistics again provides a useful analogy. Statisticians work on myriad social and environmental problems, but when they make a methodological breakthrough, it is transmitted to and evaluated by others in the statistics discipline before being published in the statistics literature. A new statistical technique developed when researching a question on climate change is then much more readily available to statisticians working on issues in drug policy or international terrorism. The aim is for I2S to operate in the same way.[26]

In time, the I2S discipline will have major professional journals and conferences where ideas are exchanged, thus overcoming the current situation where cross-fertilisation and networking are restricted.[27] It will allow research teams tackling complex real-world problems to progress from having a very limited array of concepts and methods at their disposal, to being provided with a range of options from which they can choose.

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23 It may seem bizarre to suggest the formation of yet another discipline, when the problem seems to be the inability of researchers to work across existing 'silos'; however, I argue that the challenge is to exploit, not to eliminate, the strengths of disciplines.

24 I use the word 'concept' to cover everything from a productive idea to a theory.

25 It counters the argument that integrative applied research is simply a matter of personal skill in facilitating or managing teamwork. Such skills are important, but there is much more involved.

26 Statistical insights are not evaluated by experts from other disciplines who happen to be interested in the problem the statistician is working on. In contrast, the review process for developments that could be classed as enhancing I2S is much more hit-and-miss, because there is no identifiable college of peers using the same methodology. It is common, therefore, for referees to be interested in the same problem, but to use different methods (usually from one or other discipline) in their own work.

27 This point is elaborated in Chapter 31.

Development of the I2S discipline naturally has ramifications for individual researchers. Currently those who are active in building expertise relevant to integrative applied research are hampered by the ad-hoc and constrained ability to engage with a broad range of concepts and techniques, as well as often being marginalised within the academic mainstream. Belonging to a vibrant, active discipline will not only improve their research, but also confer recognition and status. The aim is for I2S specialists to be seen as essential members of integrative applied research teams, in the same way that statisticians provide critical and respected input to teams tackling quantitative problems.

Integrative applied research teams will generally comprise investigators from relevant disciplines, including one or more I2S specialists. The role of the I2S specialists, like that of the other team members, is to provide the best available relevant information and methodology from their field. But in their case it will be about options for scoping and setting boundaries around the problem, for combining the various disciplinary expertises, for supporting policy change, and so on. The idea is not for the tasks related to integration and implementation to be left to the I2S specialists, but rather for specialists to work closely with the rest of the team to make the group aware of the activities that need to be undertaken and options for doing so. I describe the various dimensions of the role of I2S specialists in chapters to follow.[28]

Responding to the Scale and Urgency of the Task: The I2S Development Drive

Developing a new discipline is a major undertaking. The starting points are those foreshadowed earlier—namely the small amount of theoretically based research about transdisciplinarity, systemic intervention, integrated assessment and related initiatives, and the extensive existing research on complex environmental, health and other social problems, which its practitioners loosely describe as interdisciplinary, multidisciplinary, transdisciplinary or with some related term.[29] Both have devised concepts and methods relevant to I2S. The level of documentation is highly variable, as well as scattered. Nevertheless, if completed projects as well as current ones are included, I estimate that, around the world, there are thousands who could contribute pertinent material.[30]

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28 Specifically in Chapters 9, 16, 23 and 30. An anonymous reviewer pointed out that 'we need I2S specialists both in the research/science and [the] implementation/practitioner arenas', and suggested that attention must also be given to 'practitioners, policy makers, and stakeholders'. I agree, but to keep the focus manageable, have restricted it to researchers for this book.

29 Examples include CSIRO's national research flagships (<http://www.csiro.au/partnerships/NRF.html>), the National Science Foundation's synthesis centres (<http://www.nsf.gov/news/news_summ.jsp?cntn_id=121229&org=NSF&from=news>) and Australia's Cooperative Research Centres (<https://www.crc.gov.au/Information/default.aspx>) (all accessed 5 December 2011).

30 Not all of these research groups are tackling *complex* problems, but the concepts and methods they have developed often have broader relevance. This was our experience when we compiled a book of dialogue methods for knowledge synthesis (see McDonald et al. 2009). Many of the cases describe relatively straightforward issues, but the methods can be used on complex problems too.

Building I2S requires gathering together and assessing not only the concepts and methods applicable to integrative applied research, but also case examples of how these theories and techniques have been applied to different real-world problems. Examining cases is highly instructive for understanding the strengths and weaknesses of various concepts and methods, as well as when their application is most appropriate.

The challenge then is to find, collate and evaluate relevant concepts, methods and case examples from thousands of research projects. Because much of the germane material is undocumented, reviewing the literature will cover only a portion of the terrain. Further, such reviews will be resource intensive because pertinent materials are widely scattered in the published and grey literatures and are often not described in a way that makes their relevance to I2S immediately apparent.[31] Getting access to undocumented information involves different demands, especially in locating those with information and determining ways to elicit their contributions. Because existing networks tend to be small and restricted, identifying key researchers is unlikely to be straightforward. Further, given that these researchers will already have heavy demands on their time, establishing ways to make their involvement in developing I2S manageable and rewarding will require creativity and resources.

The task of compilation is therefore formidable. It also requires evaluation of the concepts, methods and case examples to decide on their relative merits. Without a well-established I2S discipline, there is currently no extensive college of peers to draw on for undertaking such assessments. The process of compilation will, however, also identify those with experience in the concepts or methods of interest. The most skilled can then be enlisted in evaluation processes.

The urgency of many of the world's most challenging problems means that we cannot afford to wait for this new discipline to evolve in the normal academic way, which could take decades. Establishing I2S can be boosted by mounting a new Big-Science-type project, akin to the effort that decoded the human genome, producing an explosion of new understanding of diseases and their cures.[32] Such an effort, referred to here as the I2S Development Drive, would be charged with identifying relevant research projects and groups, obtaining

31 Again, this was our experience in compiling a book of dialogue methods for knowledge synthesis (see McDonald et al. 2009). Most of these methods were developed for purposes other than knowledge synthesis, but can readily be adapted.

32 This Big Science project, conducted between 1986 and 2001, provided the international scientific community with a solid foundation from which to tackle the genetic bases of disease. Decoding sections of the genome occurred in individual laboratories of 20 centres across six countries. Originally it was conceived as an even broader international undertaking. It is estimated that thousands of researchers were involved (see Collins et al. 2003; Lambright 2002; Sulston and Ferry 2002; Venter 2007). A brief description of the project using the I2S framework can be found in Bammer (2008). The original 'Big Science' project was the building of the atomic bomb during World War II, often referred to as the Manhattan Project (see Rhodes 1986).

and collecting a range of concepts, methods and case examples from available literatures and research team members, as well as developing a process for evaluating them in order to produce foundational texts for the I2S discipline.[33]

The Aims of this Book

This book has the following aims.

1. To propose a structure for building the discipline of Integration and Implementation Sciences (I2S). The key elements are outlined in Chapter 2 and then described more fully in four subsequent sections of the book. Ideas for how the discipline will operate are presented in the sixth section, 'Moving Forward'.
2. To plant the seed for the I2S Development Drive as a new Big-Science-type project to establish I2S.
3. To start a worldwide discussion about I2S and the I2S Development Drive, especially the potential value, limitations, domains and operation of I2S. The commentaries in Section 7 by distinguished researchers and leaders of research organisations set this discussion in motion.

It is worth emphasising that, although the book describes some relevant concepts, methods and case examples, the focus is on proposing a structure for the I2S discipline. Populating the structure with the full range of existing theories, techniques and illustrations is the task of the I2S Development Drive, which will build the functioning discipline. The rationale for the commentaries is to catalyse the essential debate about whether the idea of an I2S discipline has merit, the strengths and weaknesses of the proposed structure, and the necessity for, and potential value of, the I2S Development Drive.

33 In the chapters that follow, I describe specific tasks for the I2S Development Drive and these are summarised in Chapter 34.

This text is taken from *Disciplining Interdisciplinarity: Integration and Implementation Sciences for Researching Complex Real-World Problems*, by Gabriele Bammer, published 2013 by ANU E Press, The Australian National University, Canberra, Australia.