# A MODEL TO OPTIMISE STATISTICAL INDEPENDENCE AND CRITICAL THINKING AMONGST RESEARCHERS IN A DIVERSE DISCIPLINARY SETTING

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*Reflective, open-minded, evidence-based decision making is a defining feature of critical thinking. The Institute of Health and Biomedical Innovation (IHBI) conducts research in diverse disciplines under qualitative and quantitative paradigms. Research methods capacity building activities must engage established as well as the majority population of postgraduate student researchers. A support model was designed utilizing a social constructivist framework and package of activities catering to various levels of statistical knowledge and phobias defined. Established and refined on the basis of three years experience, we describe the activities and relative uptake by researcher stakeholders. We suggest that this novel packaging promotes: (i) interdisciplinary exchange and intellectual curiosity, ii) more rigorous application of statistics, and (iii) professional development of team statisticians.*

## BACKGROUND

Critical understanding and application of statistical methods by non-statisticians are highly variable in any scientific discipline. Graduating competent practitioners of data analysis from service courses is an enduring challenge for statistical educators. One service course is often researchers' only exposure to statistics. Within this brief exposure need to be balanced breadth and depth of analytical issues to make them as self-sufficient as possible in the fundamentals, as well as aware of more advanced techniques to ensure they recognize the need to seek out expertise when required. Service courses tend to focus on heuristic explanations of statistical concepts and their discipline-specific applications, at the expense of underlying computations and theoretical information (Bessant & MacPherson, 2002). Constructivist approaches are popular teaching frameworks for such courses, aiming to develop critical thinking skills (Rovai, 2004). Social constructivism posits that learning is a social process involving the interaction of individuals within and across their particular community, and in the process, developing generic attributes of empathy and involvement as well as specific knowledge in context. Despite efforts in these courses to provide real-world examples in which students may identify their own experiences, the often unlinked 'avalanche' of statistical concepts to which they are exposed can be a catalyst for the statistics phobia prevalent even in established researchers. Exacerbating this, course timings are not necessarily synchronous with immediate analytical needs, distancing initial from reinforced learning opportunities, thus dissipating short-term learning. As a result, 'critical' learning of statistics is diluted to 'process' learning and educators reduced to providing relatively 'safe recipe' guidelines in the hope that students become competent in at least objective process, if not critical application (the 'art' of analysis), within the available time.

The latter is the subjective component of learning statistics that causes angst, since it requires both contextual and statistical confidence to make autonomous decisions. Angst is lessened with increased perceived statistical self-efficacy (Bandalos & Yates, 1995). Motivational models of constructivist-informed teaching highlight the importance of nurturing self-efficacy through repetitive exposure to reasonable but increasing challenges in non-competitive and reassuring learning environments (Palmer, 2005). Students with learning, rather than assessment-driven, goals achieve better examination outcomes; perceived self-efficacy mediates this relationship (Bandalos & Finney, 2003). Therefore, in a research institute where skills development is aimed at members whose sole aim is learning with a view to mastery, promoting statistical self-efficacy seems a reasonable focus for the design of strategies aimed at building research methods capacity.

## THE PROBLEM

The Institute of Health and Biomedical Innovation (IHBI), a newly-established research institute in 2006, encourages cross-disciplinary research and synergy within and across basic science and translational research agenda of five research Domains. Research topics across the Domains emphasize allied health applications–biological, medical engineering, population health.

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Whilst experimental and observational research designs are represented across the research in all Domains, experimental designs dominate the Cells & Tissue (life sciences, genetics), Medical Device (engineering), and Injury Domains. Observational designs dominate the Human Health & Wellbeing Domain, with both designs equally-represented in research emanating from the Vision Domain. In the latter three, traditions of enquiry may consider qualitative as well as quantitative approaches. One of IHBI's stated objectives is an aspiration to excellence in research training. The majority of its researcher population is postgraduate students, although there is a substantial pool of early career (postdoctoral) and established researchers.

How to best provide, sustain, and grow research methods support for this diverse population with limited resources, was the challenge. In the context of a research institute with the vision of embracing cross-disciplinary research to encourage innovation, synergy will be promoted *via* strategies that enhance networking across groups (Harvey, Pettigrew & Ferlie, 2002).

This paper describes the model that was developed to provide support to IHBI across the full range of research methodologies and methods. However, discussion in this paper will be, mostly, restricted to that around promotion of quantitative research design and statistical understanding, in essence the majority of its activities. The model synchronizes a range of activities aimed at building perceived self-efficacy in research methods, through multiple strategies that support interaction and socialization across all level of institute researchers.

An unwanted sequela of creating inviting and accessible statistical support environments, though, is the avalanche of requests for time-sapping, and generally low-level-topic, one-to-one consulting. This scenario tends to be associated with academic research environments populated with generally statistics-phobic colleagues with access to scant numbers of available statisticians. Evaluation data over three years since the model's inception demonstrate that it is contributing to intellectual cross-fertilization and the building of statistical skills of the institute community. It also demonstrates that statistical staff need not be swamped with consulting load to the detriment of their personal career satisfaction. Indeed, exposure to the breadth of research methods and support activities across an Institute can contribute to a dynamic and manageable workload portfolio that enhances staff's statistical skills and, consequently, their CV's.

## A MODEL FOR RESEARCH METHODS SUPPORT

Institutional level efforts to create a research synergy needed to be reflected in any initiatives to support cross-disciplinary research methods capacity building. The main aims were to encourage interdisciplinary exchange and intellectual curiosity about the spectrum of research methods, thereby promoting research rigor and collegiality across the whole IHBI population, from novice research postgraduate scholar to established researcher. Achieving synergy mandates that researchers across groups grow comfortable with each other's jargon and are receptive to learning about the similarities and differences in research designs and analytical approaches. This can only come from activities that encourage cross-discipline exposure.

This breadth of necessity, and implications for required range of staff expertise, had to be balanced against a backdrop of resource scarcity as the institute as a whole was being established. The final model had to involve no more than three support persons for at least the first four years in its strategic planning cycle. The group would need to cater to the above-described and diverse methodological needs of around 700 institute members. As such, mostly group activities were considered in terms of teaching and consulting.

The model for the IHBI Research Methods Group (RMG) developed on the basis of purposively-sampled and extensive local, national, and international stakeholder consultation over several months in 2006. The perception, confirmed in these dialogues, had been that few similar research methods groups existed, and that where they did, they used *ad hoc* approaches to support activities to enhance research methods capacity, rather than grounding their activities in any informed teaching and learning perspectives. The RMG model weaves the principles underpinning learning under the popular social constructivist framework into a variety of linked activities aimed at enhancing perceived statistical self-efficacy and promoting critical thinking skills. The aim of all activities was to promote mastery, rather than just competence, in levels of understanding and application of research methods across the range for all Institute members (including RMG staff).

Activities include self-directed learning, small-, and large-group discussion fora, and one-to-one consultations with RMG staff:

*Self-help materials*

These are a constantly-growing series of over 35 short 'fact sheets' around frequently-asked questions (FAQ's). They offer the most heuristic of explanations for fundamental statistical concepts, often supported by citing non-intimidating articles or texts. Self-help materials are aimed at (i) independent novices, or the timid, to get them started in private before venturing to ask questions in more public fora, (ii) redirecting under-prepared queries from those who attend clinics or consultations (being able to read this material and formulate more coherent queries reinforces self-directed learning habits and saves valuable consulting time for higher-level queries), and (iii) being a resource to which supervisors may refer their students and research staff, independently.

*Research Methods Clinics*

Clinics are facilitated by one staff member per session and run several times per week for one to two hours. They are 'cold consulting' sessions; no notice is required. Clinics aim to answer urgent, focused questions of researchers currently designing, analyzing, or interpreting their research. Sessions are designed to be as unintimidating as possible, advertised with the slogan "*No question is too simple or too complex"*. In this roundtable forum, all describe their question succinctly. The facilitator prioritizes discussion order by theming the concepts and chairs the session. All get a hearing and enough to take away to at least increment their research until the next clinic. How much gets covered depends on attendance numbers; four to five is optimal to seed real discussion and cross-disciplinary debate/opinion. Before the facilitator adds to discussion, attendees are given the opportunity to offer their opinions, or ask questions of clarification. Occasionally, this is all that is required. These sessions promote cross-disciplinary interaction and in the process affirm attendees' skills in a public setting, thus building self-efficacy. If discussion is inadequate to answer the question, or incorrect information has been offered by other attendees, the facilitator uses this as a teaching opportunity.

*Workshops*

An articulated suite of about forty, 2-hour workshop template seminars has been developed, themed into 'Research Design', 'Data Analysis', and 'Grantsmanship', deliberately emphasizing the links at all opportunities. These are refined and offered over a year's cycle and additional offerings added to align with needs-arising of IHBI researchers. For those wanting to plan a program of professional development in research methods, the workshops are ordered so that individuals may sit a complete 'course' over the year, or customize a 'course' to match their interests. Basic-to-advanced content is provided across articulated modules on most topics, although each workshop is designed to also stand alone for those refreshing or curious. Themes are diverse, but the basic 'Refresher Design and Statistics' suites continue to be the most popular and attract the most diverse group of attendees across the Institute each time they are offered.

*One-to-One Consultations*

These sessions offer deeper discussions on researchers' questions, and permit detailed analytical help when appropriate. An effective triaging system has been instigated, where all (but particularly students) are encouraged to attend Clinics and Workshops to ask their questions, from where they are referred to a consulting session if complexity warrants. Supervisors are encouraged to attend with their students, to ensure that design ramifications of any advice are thoroughly discussed and digested. In acknowledgement of deadlines driving most of their work, established researchers are prioritized. Discussion focus is on design and analytical concepts; staff do not analyze data for the researcher. Hands-on analytical help is offered occasionally, and only as a once-off 'template' for struggling researchers to encourage them to proceed independently. Consultations ensure supporting discussion and debate leave the researcher with their original questions answered, but others to ponder, thus strengthening their critical thinking skills.

*Specialist Consultations and Workshops*

Where expertise of the RMG staff is limited and advanced advice is sought, colleagues from elsewhere in the university are brought in as specialist consultants on a needs basis. To-date, this has covered one-to-one consultation advice and commissioned suite of workshops in microarray experimental design and analysis, and a series on qualitative research methods. As staff in the RMG change, specialist offerings are customized to meet changing gaps in RMG expertise.

*External Courses*

The RMG offers multi-day courses to external audiences on popular topics (e.g., research methods overviews, multivariate methods, health economic analysis). Some of these are currently being accredited as continuing education courses for various agencies. This generates income for the group and raises its public profile. At the same time, offering these intensive courses to IHBI members who attend for free is an additional strategy to efficiently promote internal up-skilling.

The explicit link between all RMG offerings is highlighted as often as possible: researchers are free to discuss self-help materials in clinics, or are referred to them in workshops and consultations in response to questions. Self-help materials are growing as IHBI members' research agenda widen, and with their development, RMG staff also grows in breadth of applications. Clinics and workshops enhance socialized learning that complements this framework so well. Attendees absorb others' contexts for questions similar to their own, thus promoting awareness of the diversity of research methods and intellectual interaction. This promotes collegiality, a growing acceptance of, and active participation in, professional critique of others' work. Both 'process' and 'art' of statistics are discussed in every forum. Some dissatisfaction is expected, and exists, when researchers are only interested in *process* and not investing in *artistic* learning.

## EVALUATION OF THE RMG MODEL

The RMG conducts annual online surveys to determine awareness, access, and perceived usefulness of the various support strategies it offers to IHBI. Open-ended comment is encouraged to highlight how existing offerings may be improved, or to suggest other support needs. These cross-sectional surveys target all Institute members, including those in non-researcher roles. Populations were 859 in 2007, 730 in 2008, and 788 in 2009. Surveys elicited response rates of 19%, 25%, and 27% over the years. Tailored Design survey methods (Dillman, 2000) were implemented: two reminder emails sent at fortnightly intervals in 2007 and 2008, and one sent in 2009 (in response to comments about 'email saturation' in the penultimate survey). As an incentive, survey completion was nominated as a task in an annual Institute-wide competition spanning multiple tasks; Domain-specific response rates accrued as points.

Current data (2009 survey, 213 respondents) suggest that awareness of the RMG, defined as awareness of at least one of its support activities, is practically saturated (96%), similarly so across all Domains of the Institute. RMG awareness was not related to time that individuals have been an Institute member, nor whether they were staff or student researchers, suggesting adequate induction, marketing and cross-referencing of activities to other Institute support initiatives.

Overall, the RMG was accessed through one or more of its support activities by 59% of respondents in 2009, but was Domain-dependent; those from life science research backgrounds accessed the RMG less (56%) than those from population health research backgrounds (71%). Student researchers (71%) accessed these support strategies more than did established researchers (50%). Length of time as an Institute member had no discernible effect on RMG usage.

Disaggregated by support strategy:

- 71% of respondents were aware of the self-help materials on the intranet. Of these, about a third (31%) had accessed them, and most (83%) found them useful. *"I didn't know about self-help materials…have to look for them now!" "My staff and students use these resources as required." "References on more sheets would value-add."*
- 87% were aware of the 'cold consultation' opportunities of research methods clinics; a third (35%) had attended at least one of these, of whom 68% found them useful. *"Depending on attendees, discussions can be stimulating and offer cross-domain insights*

*that apply equally to my work." "Found to be very useful and enhanced my work and that of my students."*

- 92% were aware of workshops run by the RMG, of whom 41% had attended at least one. Of these, two-thirds (67%) found them useful. *"Good for setting the scene on new topics and extending on known topics." "These are well presented and stimulating." "These have been informative and interesting."*
- 85% were aware of the availability of one-to-one consultations. Of these, 41% had accessed an RMG member for same, of whom about two-thirds found them useful. *"Excellent–always helpful and problems solved." "Exceptional service and necessary to cater for individual research programs."*

This positive feedback has been the norm for the last three years (previous years' data not shown) and supports that the establishment of the RMG model has been well-received and seems to meet most research methods needs of most researchers most of the time. Few specific negative comments have been offered in the requests for open-ended feedback. We speculate that this lack of detailed critique by the one-third of respondents perceiving the activities to not have been useful may be an unwillingness to criticize, a perception that answers to their questions were disappointingly not 'process' or the service at a 'doing it for them' level, or genuine inability to articulate aspects for improvement. Comments grounded in survey statements point to activities:

- being misperceived as targeted only to research students' needs. *"As a supervisor, however, it is not a good use of my time."* [about clinics]
- competing with other professional and personal commitments. *"Found it difficult to attend those most relevant due to timing, location, and own commitments."* [about the workshops]
- providing variable quality of advice dependent on staff member facilitating the session. *"Overall good, but variable depending on alignment of question to RMG staff member's area of expertise."* [about the one-to-one consultations].

Similar evaluations of RMG activities over the three years demonstrate substantial and ongoing improvement. There has been increasing awareness, although variable uptake, of the strategies, with increasing satisfaction that they are useful. In 2007, about two-thirds of respondents were aware of clinic and workshop offerings; this increased to over 90% in 2008, and remained at about this level in 2009. Similarly, awareness of one-to-one consultations was at 49% in 2007, increased to 75% in 2008 and to 85% in 2009. Amongst those who were aware of at least one of these three activities, 20-30% had attended at least one in 2007; this increased to over 50% across the board in 2008 and ranged from 35-41% in 2009. Finally, of those attending, perceived usefulness ranged from 60 to 80% (depending on activity) in 2007, to 97% or higher across the board in 2008, and returned to 2007 levels (67 to 83%) in 2009. The only strategy that was relatively less-recognized was that of the self-help materials; awareness of this offering was at 40% in 2007 with negligible change in 2008 (45%). A targeted effort to refer people to the materials during discussions in clinics, workshops, and consultations was an adequate strategy to increase awareness to 71% in 2009. However, increase in awareness was not reflected in increased use: reported access increased from 20% in 2007 to over 95% in 2008, only to return to 2007 levels (31%) in 2009. Perceived usefulness ranged from 80% in 2007 to 100% in 2008 and 83% in 2009.

Future RMG evaluations will focus on identifying barriers to statistical self-efficacy of post-doctoral and early career researchers, since these are the main generators of new knowledge in the context of a research institute. These individuals may also model more effective engagement for senior staff. Optimizing response rates of these evaluation surveys to garner more representative opinions is now critical. The latter might be better-addressed by a case (RMG users)-control (non-users) design, rather than the current cross-sectional surveys.

## RMG STAFF STRUCTURE

Critical to the success of the RMG is attracting and retaining appropriately-skilled staff, with keen interest in consulting and the breadth and depth of expertise to do so effectively. Mid-to-

advanced career methodologists are required at this early stage in the RMG's evolution, with junior staff to mentor as the group expands. There is a continuing shortage of experienced research methodologists across the country; in particular, biostatisticians. The IHBI RMG environment has been planned to be one within which professional development opportunities are many, and the expectation is that staff turnover may, as a consequence, be high. In terms of professional development, there is a customized relative emphasis of exposure to activities that will enhance research methods knowledge, consulting skills, teaching, and research collaboration opportunities.

The main element of the RMG model that attracted two staff members to join the group was the opportunity to broaden and deepen their statistical knowledge: *"[In one word,] sphericity: the opportunity to acquire breadth and depth in statistics. Due to the different needs of Domains, one has to have breadth across various statistical areas and depth since one has to make sure that advice is sound."* and *"Was attracted to IHBI to try out a new environment for a year and left a more well-rounded statistician with a lot of exposure to real-world applications. It is all well and good being able to teach a first year unit to science students […] to try to make them understand how to design an experiment well and of the practicalities they need to be aware of. However, when faced with working with real researchers, with a range of experience in their own fields, who need help with a real research proposal and […] real data, it has improved my scope […] I have to approach things from a theoretical perspective but also think about the context of the problem […]; this is something that is naturally difficult to build into teaching undergraduate statistics."*

## CONCLUSION

Synergism in research groups depends on individuals having mutual understanding of similarities and differences across their discipline areas before trans-disciplinary knowledge is generated (Travaille & Hendriks, 2010). The RMG model reflects and supports this institutional aspiration in its design by promoting cross-Domain opportunities for critical discussion about research methods in most of its activities. It is framed in constructivist ideals of affirming learning environments, and an emphasis on 'layered' learning opportunities. It attracts staff that is keen to develop professionally in both consulting and research arena. We have demonstrated that this novel packaging of support options can efficiently support diverse research methods needs within an institute population. We suggest that it successfully promotes and sustains (i) interdisciplinary exchange and intellectual curiosity, ii) more rigorous application of statistics, and (iii) professional development of team statisticians.

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