J. W. GOTTSTEIN MEMORIAL TRUST FUND

The National Educational Trust of the Australian Forest Products Industries

MAKING RESEARCH WORK THROUGH KNOWLEDGE TRANSFER

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2008 GOTTSTEIN FELLOWSHIP REPORT

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Joseph William Gottstein Memorial Trust Fund

The Joseph William Gottstein Memorial Trust Fund was established in 1971 as a national educational Trust for the benefit of Australia's forest products industries. The purpose of the fund is *"to create opportunities for selected persons to acquire knowledge which will promote the interests of Australian industries which use forest products for the production of sawn timber, plywood, composite wood, pulp and paper and similar derived products."*

Bill Gottstein was an outstanding forest products research scientist working with the Division of Forest Products of the Commonwealth Scientific Industrial Research Organization (CSIRO) when tragically he was killed in 1971 photographing a tree-felling operation in New Guinea. He was held in such high esteem by the industry that he had assisted for many years that substantial financial support to establish an Educational Trust Fund to perpetuate his name was promptly forthcoming.

The Trust's major forms of activity are:

1. Fellowships and Awards - each year applications are invited from eligible candidates to submit a study programme in an area considered of benefit to the Australian forestry and forest industries. Study tours undertaken by Fellows have usually been to overseas countries but several have been within Australia. Fellows are obliged to submit reports on completion of their programme. These are then distributed to industry if appropriate. Skill Advancement Awards recognise the potential of persons working in the industry to improve their work skills and so advance their career prospects. It takes the form of a monetary grant. The Trust also provides financial assistance to Australian Fellows at the World Forest Institute in Portland, Oregon, USA.

2. Seminars - the information gained by Fellows is often best disseminated by seminars as well as through the written reports.

3. Wood Science Courses - at approximately two yearly intervals the Trust organises a week-long intensive course in wood science for executives and consultants in the Australian forest industries.

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EXECUTIVE SUMMARY

Knowledge transfer and exchange of information belongs within the larger context of innovation and change. It forms part of the culture of both the science agency and the end-user organisation and must be addressed alongside broader topics that include performance measures and criteria for funding scientific research.

When scientific research has a policy or community focus, there is, unfortunately, minimal evidence of the subsequent adoption of that new knowledge created during the scientific discovery process.

This makes knowledge transfer difficult to measure, and thus more difficult to implement. Therefore, it is essential to have customised knowledge transfer goals as ongoing performance measures embedded into project plans, and an ongoing investment in staff time towards systems and support.

Science agencies must become more proficient in uncovering intelligent demand for new knowledge and develop a quality understanding of the knowledge needs of the users of their research.

However, the task of effective knowledge transfer lays not only at the feet of the science agencies themselves. The recipients of the new knowledge must truly wish to develop better practices and policies and actively engage with the scientific community.

The research objectives of both the science community and the users of the research should also always consider the more practical application of existing research results.

This includes identifying current research and adapting that to suit specific situations, other than those originally intended, and then transferring that knowledge. When compared with the effort and costs involved in researching new information, adapting and then applying existing research results can be a quick and easy 'win' for both parties.

Key recommendations:

1. **Build the scientists' capacity**: Invest in a quality training program for key staff on knowledge transfer and communication skills.
2. **Make the researchers accountable**: Embed knowledge transfer into all project plans and match milestone payments to the delivery of quality knowledge transfer activities (i.e. not only just the writing of a scientific report)
3. **Make the end-user communities accountable**: End-user communities should do an internal audit on their own internal innovation culture to determine if they are taking advantage of the information and opportunities currently available.
4. **Audit existing research for purposes of adaptation**: Fund the 'gaps' between research projects by pulling together existing knowledge and making it more readily available.
5. For high priority end-user communities, **investigate their needs more thoroughly**. Survey the target recipients of the research on what they need. Do not just rely on anecdotal evidence.

FOREWORD

The transfer of research findings into practice is the context for this discussion paper therefore, the definition of the terminology 'knowledge transfer' and other similar terms are made on that basis.

There are many definitions, in various academic papers, that address this topic. However, I will use excerpts from Ian Graham's paper 'Lost in Knowledge Translation: Time for a Map?' to introduce the terminology:

Knowledge transfer is about "transferring good ideas, research results and skills between universities, other research organisations, business and the wider community to enable innovative new products and services to be developed." *UK Office of Science and Technology*

and

Knowledge transfer is a "systematic approach to capture, collect and share tacit knowledge in order for it to become explicit knowledge. By doing so, this process allows for individuals and/or organisations to access and utilise essential information, which previously was known intrinsically to only one or a small group of people" *Government of Alberta.*

In addition, other terminology is often used interchangeably with knowledge transfer such as 'knowledge translation' and 'knowledge exchange'. A very useful and precise definition of knowledge translation from Canada (below) serves equally well to describe the principles behind knowledge transfer and the following concepts in this discussion paper.

Knowledge translation is "the exchange, synthesis and ethically-sound application of knowledge – within a complex system of interactions among researchers and users – to accelerate the capture of the benefits of research of Canadians through improved health, more effective services and products, and a strengthened health care system." *Canadian Institutes of Health Research.*

This definition (above) is important as it acknowledges that the knowledge transfer process occurs in a complex social system of interactions among stakeholders. It is not a unidirectional process, and involves transfer of information two-ways between researchers and users.

It also acknowledges the concept that decision making is often a social process, as the decision maker enlists the involvement of many others in the decision-making process.

Therefore, whatever term you are using, the same principles generally apply as the majority of terms/definitions have the same objective: the turning of knowledge into action, and making that work.

PART ONE – OVERVIEW

The Australian Government invests heavily in science, technology and innovation. Investment is made at multiple levels through multiple departments, at both the federal and state government level. CSIRO is a recipient of a large proportion of that investment, along with Universities, Cooperative Research Centres (CRCs) and State Government science departments.

As with any investment, the rate of return on science investments needs to be measured. Measurements are made by both the science agencies themselves and by the funders of the science. This return is measured in a variety of ways, depending on the type of science discovery.

Some common measures include a narrative of the 'impact' of that science. For example how, and by whom, the **scientific knowledge** created through the discovery process was ultimately used, and an explanation of the outcome. This is essentially describing how the knowledge was transferred.

Other measures include:

- The number of scientific papers published in high impact journals
- A measurement of the client's satisfaction regarding the outcome of a project via survey methodology
- The amount of external income from end-users of that science as an indicator of demand and/or satisfaction from previous science endeavours
- The number of licences or spin-out company revenue from the commercialised technology
- Impact of the science via detailed economic analysis

These measurements are applied inconsistently across various science projects and often randomly applied to match the needs of the particular science objectives.

Knowledge Transfer vs. Technology Transfer

Knowledge transfer is therefore one of the many objectives of a science project and often plays a large role in the measurement of return on investment. For example, the writing of a report or scientific paper and having that published can be classified as transferring of knowledge. The creation of an online tool that assists in the uptake and adoption of science is also another example of knowledge transfer. In turn, uptake or adoption of science is a precursor to 'impact', as once the science is used, it creates an outcome that is measured or reported on in the form of a narrative.

As knowledge transfer is a broad concept, I would like to follow the Laundry (2006) lead and break it down and apply the following definition. Laundry states that "Technology refers to tools for changing the environment, while knowledge embodies theories and principles helping us to understand the relationships between causes and effects. Technology is tangible and the impact of its use is precise, while knowledge can be less tangible and the impact of its use is more amorphous." Therefore:

1) Technology transfer: Applied to discrete bundles of solutions such as engineering solutions or the development of products. The objective is often the cost competitiveness of a business or gaining market advantage. The transfer methods are often a commercialisation pathway such as licensing or the creation of a spin-out company, as there is a clear economic benefit.

2) Knowledge transfer – For the purposes of this discussion, knowledge transfer is broader and more holistic than technology transfer as described above. It includes the application of the collective wisdom and is often applied to benefit end-users through the development of best practice processes and policies.

When informing best practice activities, often the process draws upon multiple sources of information and is essentially an ongoing exchange of information. This requires two-way communication via a mix of different communication tools and methods. These broader knowledge transfer activities are predominantly applied to environmental or socially driven science (as opposed to science for the enhancement of economic benefits as per technology transfer above).

Often the issues being addressed are complex and require multi-disciplinary approaches in order for knowledge transfer to be successful. The development of best practice activities is highly dependent upon full information sets, and requires knowledge from both within discrete projects and across a variety of ongoing projects, including the gaps between those projects.

Therefore, in a traditional science performance measurement setting, if in organisation were to only focus on the transfer of knowledge at a project by project level then the knowledge transfer for best practice policies and procedures would be sub-optimal.

Knowledge Transfer activities in CSIRO

For the purposes of this discussion, we will not address technology transfer any further as that path is well worn. Intellectual property (IP), licensing and commercialisation activities are all generally handled professionally and efficiently in most organisations, including CSIRO.

However, for knowledge transfer, CSIRO does not appear to have a systematic and rigorous internal support program that draws upon the information created across multi disciplinary projects. Nor is there a support program (other than for some Flagship research, in particular water research) that is dedicated to the two-way exchange of information to facilitate best practice objectives.

Knowledge transfer in CSIRO is the responsibility of the various science leaders, and each science leader is charged with either a specific portfolio of activities or individual projects. Science leaders are then charged with determining the best path to impact. Some science leaders, particularly in the environmental portfolios, have been very successful in implementing knowledge transfer initiatives, particularly in the water research fields.

These leaders have given knowledge transfer a high priority and implemented significant programs and dedicated resources to the task. However; the learnings from these

successful activities are not systematically captured, nor then applied to assist the broader community of science leaders within CSIRO.

Industry pulls knowledge through vs. Science pushes knowledge out

However, science agencies like CSIRO are not going to automatically invest in knowledge transfer activities without evidence of some demand for that knowledge.

For example, if the forest industry is no longer investing in a particular sawing technique then CSIRO is unlikely to invest in further research, nor in pulling together all the past research to inform best practice objectives.

End-user communities also need to demonstrate both a willingness and an ability to receive and translate information for their own benefit. This 'pull' for knowledge is essential for effective knowledge transfer.

Once there is demonstrated demand for knowledge, this then needs to be matched by the science agencies. The science agencies should then resource and reward the knowledge transfer activities and 'push' the information out externally beyond their own organisational boundaries.

Science culture and funding structures

Each science organisation has a certain culture and funding structures. Therefore, it is important to acknowledge and understand how those cultures and funding structures either encourage or discourage knowledge transfer activities.

The measuring and rewarding of certain behaviours is a key driver behind performance outcomes within any organisation. However, this has to be established with full respect and a thorough understanding of what motivates scientists. If external income is measured and rewarded then effort will be expended seeking that external income at the expense of other activities. If the number of high impact science journal articles is measured, such as for promotion criteria within CSIRO, the same will apply.

Therefore, performance measures and organisational goals and priorities play a critical role in the fostering of knowledge transfer objectives.

For example, the competitive funding process for research projects creates a very strong internal objective. The securing of external funds for research projects is required to meet budget (and secure staff levels) and the generation of new projects that attracts that funding is paramount. However, is similar attention paid to the application of current research, and making that research work?

Once scientific information is created and knowledge is gained through scientific discovery, often the primary knowledge transfer activity is the writing of a scientific journal article and/or a research report specific to that project.

The writing of a report or scientific paper is a common form of knowledge exchange that is very successful within and across the scientific community. This form of exchange is supported internally within many science agencies. Publication rates are often used as the basis for seeking employment elsewhere or a promotion.

The knowledge exchange between scientists themselves is a well worn path of both peer review and publication. However, this is often not the most appropriate form of exchange with other communities.

The scientists are being rewarded for focusing on publishing papers, at the direct expense of knowledge exchange to a broader community across multiple disciplines. Therefore there is an opportunity to align performance measures with broader organisational objectives (such as 'impact' from the science) in order to be better stewards of the knowledge being created.

An internal analysis can be undertaken to determine whether a science agency is maximising the opportunities from the knowledge created.

Potential future strategies that draw together knowledge from a variety of sources to benefit best practice objectives in an industry or community, and/or policy development, requires resourcing and prioritising by science leaders.

It also requires support by the organisation at large through the provision of knowledge transfer professionals and systems to assist the activity in a streamlined and efficient manner.

PART TWO – CANADIAN EXAMPLES

The purpose of my study was to explore best practice knowledge transfer activities in Canada. I focused on two groups within the Canadian industry, the Canadian forest industry and the broader Canadian innovation system.

Examples from the Canadian forest industry

FP Innovations is a major research provider for the forest industries in Canada and is the product of a recent amalgamation of Feric, Forintek and Paprican into the one entity. FP Innovations is structured differently to CSIRO and has a membership base incorporating approximately 80% of the Canadian Forest industry. Individual forestry, timber, pulp and paper companies pay annual membership fees and in return receive the knowledge generated from research projects.

This membership-based model lends itself to significant input from member companies regarding direction setting and execution of research programs. As a result, FP Innovations has a significant program of knowledge exchange for and on behalf of the members, including the use of knowledge brokers, industrial advisors and extension personnel. For example, when asking how much time was spent by staff on knowledge transfer, the answers across the various divisions were in the vicinity of 25 – 50% of scientists' time.

As the amalgamation of the three founding companies takes its course, FP Innovations will capitalise on best practice across the three divisions and implement that one best practice across the entire organisation, including knowledge transfer activities. One of these practices may be the sector driven advisory groups, another may be the report card system, whereby each member company is given an end of year 'report card' detailing the projects that have benefited them and their operations, including other research that may be of future benefit but yet to be adopted. Tailored summaries like these that identify and quantify the value exchanged in the past can only be developed from a strong foundation of past mutual exchange.

Standardising best practice across the three divisions will not be an easy task as the various member companies themselves, along with the funding sources, are heavily regionalised. The Canadian provinces (similar to Australian States) invest heavily into research and development and each province has its own set of criteria and objectives. This makes optimising and streamlining knowledge transfer activities difficult, as the staff who are dedicated to knowledge transfer are pulled in different directions by the different provinces.

FP Innovations works across the full forest industry value chain, from in-ground forestry and tree establishment through to harvesting, processing and then value adding including paper and biorefineries.

An observation from FP Innovations, relevant to the topic of knowledge transfer, was that those research projects that involved in-forest discovery or experiments were much easier to translate the knowledge and benefits from, than those research projects that were laboratory-based. This is because the scientists had to work in partnership with industry for access to those forests/personnel. Those partnerships were then founded on mutual value and knowledge exchange. Industry would then create ongoing demand for

that knowledge being created due to a heightened awareness of the objectives and the value of the research.

This example serves to demonstrate that knowledge transfer is not an activity that is necessarily 'bolted on' to the end of a research project. Rather, it forms an integral of the entire project during its full life cycle.

The Canadian forest industry is currently in decline due to a variety of factors, namely a depressed US economy and reduced housing starts. In addition, over the last couple of decades there has been a significant change within the forest industry landscape. This includes the consolidation of the processing sector evidenced by the establishment of large super-sized mills at the expense of lots of smaller mills. As a consequence, raw materials need to travel further, as do the finished products, consuming more oil/gas in the process.

As forestry companies down size and cut departments in this current economic climate, the technical receptor capacity (namely qualified engineers and technicians that understand scientific research) within those organisations is largely diminished or completely extinguished. Therefore, from a knowledge transfer perspective, the capacity of the industry to receive and translate technical information is compromised and there is a greater burden upon the science providers to also translate the information, in addition to conducting the science discovery.

This is a real issue for research providers such as the University of British Columbia, home to one of the largest forestry schools in the world. It has addressed this challenge through the establishment of collaborative centres for specific sectors. Its Centre for Advanced Wood Processing has been a good model for training the future leaders of the forest industry as well as educating the current industry through the transfer of recent and ongoing discoveries.

A significant investment was made by the Centre for Advanced Wood Processing, whereby large, complex and expensive machinery was procured for the benefit of education and research purposes. The equipment was sponsored by the manufacturers themselves, primarily for demonstration and testing purposes. As a consequence, the centre has at its disposal some of the latest equipment to improve knowledge through research and demonstration / testing activities. The manufacturers are also advantaged by having the industry trained on their machinery, making adoption more likely due to familiarity. In this example, knowledge exchange occurs more readily and efficiently due to the engagement of multiple parties and everyone's commitment to mutual value.

The above example is more relevant to an educational institute such as a university, rather than a Government science agency, as a university has knowledge transfer to students as one of its core objectives. These students then also become ambassadors of the new knowledge created and take that knowledge with them into industry. The university also has the advantage of utilising some of its investments in online education tools to advantage the broader industry.

Examples from the broader Canadian innovation system

The University of British Columbia has a University – Industry Liaison Office which works across all the faculties, focusing on both knowledge transfer and technology transfer of research outputs. Due to the breadth of its activities the office firmly believes that there is no one single approach towards effective knowledge exchange. Instead, one should have a full suite of tools and multiple channels in order to 'mix and match' efforts based on the particular circumstance. One successful model mentioned is a structural arrangement called an affiliate program, whereby a number of organisations invest collectively alongside researchers and help direct research and knowledge transfer objectives, similarly to the Cooperative Research Centre (CRC) model in Australia.

Another successful knowledge transfer method is the application of new knowledge into a prototype format, and offering it free through a subscriber base, i.e. via the web. The knowledge is then road tested by potential adopters and feedback is provided on a regular basis. This creates future demand for updated versions as the knowledge becomes more and more useful within the end-user community. Value is also provided back to the researcher due to the feedback loop.

The university understands that good metrics are required to truly evaluate the effectiveness of knowledge exchange activities. It is easy to measure the number of spin-out companies or license agreements from technology transfer, however because knowledge transfer is a continuous improvement loop, measurement can get quite tricky.

Environment Canada, the federal agency that incorporates policy and research activities for the environmental benefit of the nation, has funded a small team to engage specifically in knowledge transfer activities. This team is focused primarily on informing policy development and works with municipal / local council groups as well as other stakeholders.

The knowledge transfer team differentiates itself from the corporate communications team in several ways. The corporate communications team is primarily focused on public relations, whilst the knowledge transfer group is focused on sustained dialogue between stakeholders.

A recent paper co-authored by members of this team states that "science must be socially distributed, application-oriented, transdisciplinary and subject to multiple accountabilities. From a one-way linear process, science is evolving to a multi-party recursive dialogue". This team is therefore modelling knowledge exchange on that basis, and it is a unique program given that most other science agencies primarily focus on traditional communications, namely public relations.

The uniqueness of the program however throws up some of its own challenges, namely how to measure the success of the team's activities. Environment Canada has recently changed its internal structure and is now focused on outcomes by way of a matrix, and the team is finding it difficult to get traction internally at the senior level regarding support for the future.

Moving from natural resources to the health sector, when talking with the various knowledge transfer specialists within the Canadian health sector I was struck by the maturity of the topic within this community. The language being used, the tools being

developed and the body of knowledge on the topic were significantly more advanced. The primary objective throughout was better policy outcomes within the health sector.

The Sick Kids Hospital in Toronto has quite a few knowledge transfer programs and has invested in a significant training program that teaches scientists skills on how to engage in knowledge transfer activities. This course was the first I have come across that was tailored towards enabling the scientists to do the transfer themselves, as opposed to providing intermediary programs or resources to do this for them. The training materials being developed include checklists and templates that could be easily adopted for research other than in health.

Other health research professionals, such as those at McMaster University, are furthering the body of knowledge on understanding end-user communities' needs. Without a thorough understanding of the needs of the recipients of the knowledge, and their preferred methods of receiving that knowledge, one could argue that efforts in this area could be largely wasted. Therefore, armed with a strong understanding of their target audience, the team at McMaster University has embarked upon a program using a suite of tools, including tailored messaging at appropriate time intervals.

Knowledge transfer communities in the health sector frequently used terminology such as 'evidenced-based decision making'. During the University's research into the end-user communities needs, such as those in policy making departments, the decision making process within those departments were analysed. Predicting how program decisions get made through both qualitative and quantitative interviews at various levels within the department will help the scientific researchers better target their knowledge transfer activities in the future.

The Canadian Health Services Research Foundation (CHSRF) has been a leader in the field of knowledge transfer in Canada over the past decade. It had initially focused its attentions on building the capacity of its researchers, i.e. delivering communication and engagement training workshops amongst other activities. Its focus on the 'pushing' of research into communities quickly changed when it deduced that this was only one side of the equation. One of its many innovative approaches towards creating 'intelligent demand' for knowledge is the recent creation of an Executive Training Program for Research Application. Senior managers from within the health industry apply for this 2 year fellowship program aimed at capacity building within the end-user community.

The CHSRF was helpful in lining up the majority of my health sector interviews. It also introduced me to a knowledge brokering group within one of the Health departments in Montreal that has taken a very practical approach to knowledge transfer. The objective of this group is to make accurate information accessible and relevant for purposes of changing best practice. The team members are given the titles of knowledge brokers and their 'clients' are the key decision makers within the health sector in the Quebec province. These decision makers have been identified by the department via various 'round tables' of senior executives.

The interesting approach taken by this team is that it takes a strong vetting role in the process of deciding who to take on as clients. Armed with a strong understanding of the decision making process within their clients' organisations, a prospective client essentially gets a 'grilling' on why it wants to adopt knowledge, and whether it is just for information or if it really is for changing to best practice. They are also evaluated on

their personal motivations; whether they are just going ‘through the motions’ because their boss told them to or not, and also whether they have the fortitude to manoeuvre through the many layers of bureaucracy to effect change. By carefully selecting its clients this group has a strong success rate in transferring knowledge and that knowledge being adopted into best practice.

PART THREE

During my travels and various domestic conversations I was exposed to a variety of examples, incorporating many different scenarios. The exposure to these examples has helped me focus on the future application of knowledge transfer activities for the benefit of all parties. This last section of my report addresses the challenges and opportunities regarding the implementation of knowledge transfer.

Building knowledge transfer activities into the research life cycle

We all live in a heterogeneous environment, where most things originate elsewhere. This is especially true of the research environment. Scientific research is a continuous loop of improvement, where discoveries are built off the backs of discoveries from the past.

However, research projects need to be managed as a discrete lifecycle with a start and end date in order to be project managed efficiently and effectively. When putting together a research plan, knowledge transfer needs to be an essential element within that research plan.

Research 'outputs' are measured at the completion of a research project, often shortly after the termination of that project, in say one or two years after commencement. Those outputs may incorporate knowledge transfer elements, however often these outputs are measured as tangible units such as number of reports or scientific papers.

Alternatively, research 'outcomes' result from the research being adopted and these are a better measure of knowledge transfer. Outcomes usually occur some time after the commencement of a project, say in four to five years time, as adoption is a long term process. Given the time-frames involved, it is often difficult to incorporate these measures into project plans.

Therefore, it is important to think of knowledge transfer at the very start of a project. When building knowledge transfer into project plans it is important to distinguish between outputs and outcomes and have strategies to cater for both. Some further elements to consider when incorporating knowledge transfer into your research plan include:

- The culture behind rewards and performance management within a large science organisation must also actively support and nurture knowledge transfer goals. i.e. is the project being established going to receive recognition for the knowledge transfer goals, or is it targeted towards other goals such as scientific excellence?
- Resourcing: Does the research plan adequately recognise the resource and time commitments required in order to deliver effective knowledge transfer objectives?
- Has the project leader consulted with knowledge transfer or communications specialists whilst developing the project plan, and engaged their support on the delivery of those objectives?
- Does the plan identify a decision maker partner from the end-user community that will benefit from the research, and will they be engaged early in the process? An example of a successful model of this is the highly effective steering committees put in place by the Forest and Wood Products Australia. When these steering

committees involve committed industry representatives the transfer of knowledge is greatly enhanced.

Building knowledge transfer into the organisational fabric

As established above, we are often managing research on a discrete project by project basis. Therefore it begs the following question; Who is responsible for the knowledge being formed collectively as an organisation over time, the knowledge being formed between the projects, in the gaps?

Is the organisation supporting and nurturing the identification of knowledge opportunities? And if so, whose responsibility is it to identify those opportunities, and subsequently adapt that research in order for it to be adopted via knowledge transfer mechanisms?

The Canadian Health Services Research Foundation focuses on adapting previous research and then facilitating the adoption of science, as a cost effective alternative to embarking upon new research. It firmly believes that this is an important role and an 'easy win' given that the majority of the financial investment has already been made in the discovery process. The incremental cost of adapting that knowledge and disseminating it is subsequently 'good value'. This is a potent example here.

The culture of an organisation and its rewarding mechanisms play a large role on this matter.

Knowledge transfer tools:

When exploring knowledge transfer tools I quickly found that there is no one 'magic silver bullet' tool that every researcher should use, unfortunately. Multiple knowledge transfer strategies are required as all strategies work at least some of the time. The most efficient approach to implementing knowledge transfer strategies involves a thorough assessment of both the salient barriers and supporting mechanisms found in each individual context.

Knowledge transfer can be enhanced via research structures that foster knowledge transfer objectives. This is different to the various tools that can be applied to various research endeavours.

1. Some examples of research structures that nurture knowledge transfer:

- Collaborative research business models such as CRCs and membership-based cooperatives.
- Education-based models such as research being conducted alongside education activities in universities.
- Business incubation models such as spin-out companies (more relevant to technology transfer than knowledge transfer in this discussion)
- Funding structures and milestone payments of individual research programs i.e. milestone payments upon completion of knowledge transfer elements.

2. Some examples of effective knowledge transfer tools and programs applied to research projects (in no particular order):

- The development of '**online communities of practice**' where people can gather on websites and share information i.e. intranets and wikis. These need to be actively nurtured through regular inputs of information.
- The establishment of specific roles such as **knowledge brokers** (addressed later in this report). These people primarily:
    - Are a go between, middle person or group that facilitates ongoing exchange.
    - Match research/ers with end-user groups when there is a true desire to change practices.
    - Assist end-user groups to build capacity (technically and culturally) to be able to critically appraise information at various levels within their organisation.
- The development and **delivery of tailored information** and messages on an ongoing basis.
- The establishment of **effective knowledge exchange partnerships** that include sustained personal interaction between both researchers and end-user communities. These can be facilitated by either the researcher or the end-user. However, the key issue here is sustained dialogue as opposed to one-way passive communication.
- **Events and Forums**. i.e. the creation of symposia in partnership with key decision makers within the end-user communities.
- Effective **demonstration strategies** by using early adopters in select communities, i.e. releasing early prototypes or significant parcels of information to create a demand for further information.
- The creation of **special interest groups** such as advisory boards and steering committees that interact on a senior level over and above specific research projects.
- **Capacity building** such as training the scientists in communication and knowledge transfer skills, in order for them to deliver these activities on their own accord at a later date.
- Scientists can also **lead a controversial debate** by taking a strong scientific viewpoint and become a catalyst for change. This is a risky strategy and often reserved for transformational change on key controversial concepts e.g. water reform and the Wentworth group.
- The provision of **written reports and presentation at established events**. This is currently the most frequently used method of knowledge transfer within most scientific communities.

Barriers to effective knowledge transfer

Choosing the right knowledge transfer tool/s for the right situation requires a thorough understanding of the end-user community with which you wish to engage. Choosing the right tool/s also requires a good understanding of the barriers to effective knowledge translation. The following is a list of common barriers, in no particular order:

- **Language, cultural and/or educational barriers** within end-user communities, particularly if the science has an environmental or social outcome and indigenous communities are involved.
- **Internal performance measure barriers**. As mentioned previously, if scientists are only measured on the number of science papers and or science excellence objectives, then that is all that will be focused on.
- The **lack of evidence** of effective knowledge transfer can also become a barrier i.e. even when knowledge transfer is positively identified as a performance measure there may still be a barrier to implementation due to the lack of evidence of success.
    - When the science has a commercial application the technology is often transferred via commercialisation, licensing and spin out companies, all of which can be readily measured. However,
    - When the science has a policy or community focus then there are not as many readily available, nor quantifiable, evidence measures that demonstrate quality knowledge transfer is occurring.
- The **assumption that there is only one targeted message** out of any one piece of research can often become a barrier. There are in fact multiple messages for various groups, or levels within various end-user organisations, and these need to be cultivated and targeted to these various stakeholders.
- **Competitive barriers:** Often engineering solutions and technical solutions are kept confidential by individual companies, industries or nations in order to establish a competitive advantage. This is, of course, contrary to knowledge transfer objectives.
- **Lack of clarity regarding whose responsibility it is to invest** in knowledge transfer activities becomes a significant barrier in some circumstances. Often research is a long process and interdisciplinary in nature. The research may cross many organisations and get handed from one researcher to another in an opportunistic manner. In addition, often there is knowledge in the gaps between the research projects. Therefore, how can a funder of the research mandate that any one group or individual is responsible for the knowledge transfer when it is this complex and many years before knowledge transfer may be required?
- The lack of any **technology literacy** within the end-user community makes it much more difficult for research to become adopted when the research is complex in nature. Therefore, larger organisations are often easier to transfer knowledge to, over and above smaller organisations, as they will often have their own in-house expertise to help with the adoption process.
- **Low capacity and/or knowledge transfer skills** of the individual scientists involved in knowledge transfer activities is a significant barrier.
- **Maturity level of end-user communities**. Immature communities of practice who are not used to collaborating with researchers will be very hesitant and resist researcher efforts initially. More mature communities will display early champions to assist in the process.
- **Intellectual property constraints**: Entrepreneurial activity is becoming more prevalent in our community and the resulting focus on the protection of intellectual property (IP) can impede knowledge transfer objectives.
- **Financial resources**: The production of knowledge requires a large variety of resources, including financial resources. The transfer of knowledge also requires resources and in a resource constrained environment is often sacrificed.

- **Not identifying the appropriate decision maker partner for the research**. A decision maker partner is a key person of influence from within the end-user community. If there is no decision maker partner engaged by the scientist during the research project life cycle, or an ineffective partner is chosen, then this becomes a barrier to the implementation of knowledge transfer. An example of the importance of this topic is that the CHSRF mandates the identification of a lead decision maker partner and regular interactions between the latter and the lead researcher in order to foster a sustained and mutually beneficial dialogue. If this does not occur the research project does not get funded!
    - If the decision maker partner has no authority to implement change within their own organisation this can also become a barrier to success.
- A **lack of understanding of the needs of the end-user community** makes for an ineffectual knowledge transfer program. The importance of engagement and background research into the needs of the end-users cannot be underestimated. The researcher also needs to take into account their capacity to retain initial information, and adjust strategies to implement multiple programs and messages to repeat information if that capacity is low.

This last point is well understood by most in the innovation environment, and leads us to the next section. As pointed out by Rogers (2002), "The fundamental difficulty in the technology transfer process traces to the dissimilarity… of the participants in the process". Therefore, one of the major determinants of knowledge transfer is the linkages between researchers and end-user communities.

Ensuring that the end-user communities are 'pulling' the information through

In order to foster and encourage end-user communities to engage with researchers there needs to be an understanding of the value of that engagement. This is a critical component to the knowledge transfer process however, even if the value is well understood, there are also other barriers. For example, a community may not be able to engage due to a downturn in the economic climate and subsequent lack of capacity, therefore any or all efforts in knowledge transfer may become totally inappropriate.

Recognising and understanding end-user community needs is therefore essential in the successful implementation of knowledge transfer activities. Some factors to consider regarding the suitability of end-user community engagement include the following:

- The **awareness levels** in the end-user communities of knowledge transfer activities and the value of such activities. If there is a high awareness in the end-user community of the value in expending efforts to adopt best practice based on research outcomes, then this of course is going to be beneficial to all parties. There are some excellent 'self evaluation tools' developed by the CHRSF that walk organisations through their own internal culture regarding this topic, and have been used with some considerable success in the Canadian Health sector.
- What are the **motivations** of the end-user community? Are those motivations dominated by commercial and/or market driven objectives or are they driven by best practice (policy, environmental or social) objectives? Once this is understood then it is easier to match different communities with various research organisations or groups as appropriate.

- Where does the **funding for the scientific research** come from? Is scientific research predominantly funded from compulsory levies that are then managed by one collection agency (i.e. Forest and Wood Products Australia) or is there an established history of individual firms investing in scientific research themselves to achieve various objectives. If a community is predominantly levied and the control of those funds is taken from their individual hands, the science agencies may find it more difficult to engage with them collectively, and spend more time engaging with the levy collection intermediary agency. This in itself isn't a bad thing of course, if the levy collection intermediary puts in place effective knowledge transfer activities to compensate.

Once knowledge transfer is embedded into research project plans, then the adoption of that knowledge often takes its own unique path. The path taken within end-user communities is dependent upon many factors however, the stages it goes through forms a familiar pattern as per below:

- Stage 1. Total resistance to change / adoption - particularly if there are significant policy and investment changes required.
- Stage 2. Bureaucratic resistance – particularly in larger organisations, where some employees within the department 'go through the motions' but don't support real change. This is a dangerous phase where many projects fail because often those involved in transferring the knowledge don't recognise and counter this type of resistance. It is critical that senior change champions from within the department or organisation address this phase.
- Integration – the education process and the 'tipping point' towards adoption.
- Embedding the tool or the process – often through communities of practice and the ongoing consistent efforts of significant senior change champions.

Please note, these stages are particularly relevant to projects that aim for the adoption of best practice in national systems (i.e. Environmental policies at a national level).

Knowledge brokers

Understanding the value of knowledge broker programs was one of my specific interest areas prior to setting forth on this journey. Knowledge brokers are intermediaries, people who hold a role specifically directed towards the brokering of information between researchers and end-users of that research. Knowledge brokers are similar to extension officers, industry liaison officers and other intermediary roles. These roles require specific skill sets that enable the exchange of information, and the success or failure of many knowledge brokering programs is often attributed directly to the skills of the people involved.

Knowledge broker programs are generally a component within a broader knowledge transfer program. As we know, often the scientists themselves are engaging in knowledge transfer without the aid of a middle person, and through targeted efforts are creating communities of practice. However, when the scientists do not have the time, nor the skill sets, knowledge brokers are engaged to make sure people meet and engage, effectively acting as a middle person.

The skills essential in filling a knowledge broker role include:

- **Communication skills:** Extremely strong interpersonal communication skills are required to bridge the gaps between scientific researchers and the end-user community.
- **Technical capacity:** The ability to understand complex scientific and technical issues in order to subsequently translate that information.
- **Translation skills:** The ability to translate complex information so that it is understood by different parties. Also required is the ability to translate the needs of various parties, i.e. the end-user community needs for research.
- **Project management skills**: The ability to follow through on various opportunities in a comprehensive manner, and meet the needs and expectations of various parties, requires a systematic approach to each and every engagement, including strong record keeping.
- **Adaptability** and **respect**: Given that the role will be crossing various community boundaries, including different cultures, the person filling the role requires the ability to adapt and connect on various levels.

There are a few different types of knowledge brokering programs and roles in different scenarios both here in Australia and overseas, many of them adapted to meet the needs of the individual organisation funding the program. The knowledge brokering concept however is not limited just to individuals; in some circumstances whole organisations are set up to become intermediaries to foster the exchange of information, such as Forrex in Canada. In some regions these are called 'boundary organisations'.

Forrex in Canada is a not for profit cooperative established in 1998 to provide knowledge solutions to the natural resources sector. Forrex funding primarily comes from the province of British Columbia however, it is also funded through grants and in-kind contributions. The structure is relatively flat and it utilises many extension officers located in the regions where the information is needed.

When exploring the value of investing in knowledge brokering programs, including intermediaries and boundary organisations, it is useful to understand the multiple advantages and disadvantages of these programs. This will then enable one to plan and manage for these, if considering embarking upon such a program.

The advantages and disadvantages of knowledge brokers and intermediaries collected during my travels from those who have had prior experience with similar programs are summarised in the table below.

Advantages of intermediaries	Disadvantages of intermediaries
You have engaged ***experts*** who are far more likely to succeed in having research adopted, than those with minimal experience in knowledge transfer.	Difficult to fill the roles with people who have the specialist skills outlined above. Some argue that it is easier to teach technical people communication skills as opposed to the other way around.
The engagement of experts allows the scientists greater time to specialise in their area of expertise, scientific discovery.	Sometimes the message get's garbled i.e. 'Chinese whispers'.
Knowledge brokers get involved in the science from the beginning, rather than at the end, and therefore add more value.	The end-user community may become frustrated as it may not always have direct access or dealings with the scientific expert.
Knowledge brokers do all the 'hard work' as it is generally acknowledged by many that engagement and knowledge transfer is a significant work load often overlooked or misunderstood by those not engaging themselves personally.	Some individual scientists feel threatened, disadvantaged or hampered because they are not in touch with the end-user community directly on a regular basis.
An investment in knowledge brokers often then aids in the development of a centralised service that can produce things like events and newsletters more readily and with greater quality.	Dependent upon which group is funding the knowledge broker, the efforts of that knowledge broker could become dominated by sectoral or regional objectives.

Further observations regarding knowledge brokers and other intermediaries such as boundary organisations include:

- Older scientists are less resistant to intermediaries as they themselves have already had the time to make a name for themselves in a particular area of expertise, whereas more junior scientists at early-career stage tend not to want to leave that engagement up to others, for fear it may slow down their own career path.
- More and more people I talked with are recognising the need to facilitate the scientists to do the engagement themselves, as opposed to doing the engagement on their behalf via intermediaries. An observation is that many boundary organisations are now investing in capacity building to enhance both the science communities and end-user communities' skills and abilities, **as well as** continuing to broker the knowledge.
- Measuring the success of an intermediary is very difficult because most agree that the researchers creating the knowledge should ultimately take the credit for creating impact from the adoption of that knowledge. Therefore, if an intermediary gets too visible then they essentially take the limelight away from the science. The flipside is, however, if the intermediary is too invisible then the success of that program is misunderstood and is under threat regarding future funding.

Choosing the right knowledge transfer program for the right situation.

So if knowledge brokers are not the magic silver bullet, then how does one evaluate all the options and choose the right knowledge transfer program to fit the right situation? But before asking yourself that question, you need to ask yourself are you ready to invest?

Ultimately the decision to embark upon such a journey begins at the top, because unless there is a strong commitment to knowledge transfer then it becomes a difficult program to implement. This is because the measures of success are so difficult to identify.

So, prior to investing in a program there needs to be culture shift and knowledge transfer must be prioritised, and performance measures embedded into each and every scientists' assessment process. Because we all know that what gets measured, gets done.

The performance measures, however, need to be flexible enough to cater for differences in circumstances and different scenarios. For example, in some sectors you may have the best science in the world but if the industry is not capable of adopting that knowledge due to variety of reasons (i.e. economic downturn, etc.) then there will be no knowledge transfer, through no fault of the science community.

Once the culture and framework is set accordingly, then the investment begins in knowledge transfer strategies and programs that meet the needs of the different science and end-user communities. Ultimately, as Laundry states, "knowledge transfer should be conceptualised and operationalised as a series of activities that nourish decision-making" rather than focusing on a single stage of the decision making process.

Next steps

If you are interested in pursuing more information on this topic, it is essential that you engage your colleagues. Learn about their opinions on the importance of knowledge transfer. Also, learn what they have done in the past and what does or doesn't work in your organisation or industry.

By starting the dialogue on the topic internally, with a wide variety of your colleagues, you will raise awareness on the topic and hopefully generate interest going forward. Gathering support for knowledge transfer is essential in the future implementation of strategies.

I have included a few discussion starter points as appendices in the next section to assist in those conversations going forward.

Appendix 1

DISCUSSION POINTS for INDUSTRY and POLICY MAKERS

- Are you time poor, information over-loaded and only need to know what you need right now? Consider dedicating one person within your organisation that is responsible for 'harvesting' different information sets from within science organisations. i.e. Create a 'go to' person who will evaluate any new reports that are released by science agencies. This person can then find out what it means for your organisation and inform the relevant people.

- Dedicate time to participate in events and meetings that involve scientists

- Get to understand the full innovation road map in Australia. Note: It isn't just one organisation that is making a contribution. In the forestry example there is the Forest and Wood Products Australia, CSIRO, CRC's, Universities and then of course there are the many international organisations as well. Do you know their general programs and special interest areas relevant to your needs?

- Categorise your needs prior to engaging with scientific researchers. If you need a technology solution then a science agency will treat that request differently from a general knowledge type request.

- Do a self assessment by using a tool such as 'Is research working for you?' and understand how you can improve as an organisation in utilising the knowledge already available.

- Are you naturally sceptical about the relevance or efficacy of scientific research because it isn't conducted by industry folks such as yourself? And if so – have you truly challenged that assumption by engaging with research projects to ensure that they are relevant?

- If you are involved in funding a research project, think about your requirements and build into the project knowledge transfer activities and regular meetings. Attach various criteria such as knowledge transfer to milestone payments.

Appendix 2

DISCUSSION POINTS for SCIENTIFIC RESEARCHERS

- Have you had recent training in knowledge transfer and communication skills? If not, ask for training at your next review; you will have a better chance of receiving training if you are pro-active and ask.

- Do you build knowledge transfer activities into all project plans and ensure that these are linked to milestone payments.

- What knowledge ASSETS have you created? And what do you know about the uptake and application of that knowledge among your target stakeholders?

- When identifying users for your research, have you also identified potential users that are currently unconnected to the research? And then developed strategies to reach those harder to engage groups?

- Have you planned for and engaged with users of the science along the width and breadth of your project as opposed to just at the end? And have you engaged in a truly integrative manner as opposed to just a few touch points? Choosing the appropriate person from the end-user community to become your 'decision maker' partner can significantly aid your efforts in knowledge transfer.

- Building one-on-one relationships is the most effective and efficient way to transfer knowledge. Are you putting yourself outside your comfort zone and making sure that you dedicate time to this activity?

- Do you truly believe that the one-way flow of written material (such as a scientific report or paper) is effective transfer of knowledge? If so, then challenge yourself and use your investigative powers to ask your stakeholders what they believe is effective, and get an understanding of their needs prior to making any assumptions.

- When developing a project plan, have you considered the potential to adapt current knowledge to suit a particular scenario and then dedicate your time to the transfer of that knowledge – as opposed to creating a new research project?

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