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► **To cite this version:**

Allen Alexander, Stephen Childe. A Framework for the Transfer of Knowledge between Universities and Industry. Jan Frick; Bjørge Timenes Laugen. International Conference on Advances in Production Management Systems (APMS), Sep 2011, Stavanger, Norway. Springer, IFIP Advances in Information and Communication Technology, AICT-384, pp.534-548, 2012, Advances in Production Management Systems. Value Networks: Innovation, Technologies, and Management. .

HAL Id: hal-01524226

<https://hal.inria.fr/hal-01524226>

Submitted on 17 May 2017

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A Framework for the Transfer of Knowledge between Universities and Industry

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Abstract. This paper describes research to examine the process of knowledge transfer between universities and industry, where the transfer of knowledge can be a valuable source of innovation for a company, in terms of new product development (radical innovation) but also as a source of knowledge for process or product improvement (incremental innovation). The view is adopted that the most useful knowledge for industry is knowledge that leads to action, known as tacit knowledge. However, tacit knowledge is seen as the most difficult type of knowledge to transfer. The paper builds on the research in this area of strategic knowledge management and uses case-study style research to review a framework that shows how knowledge can be codified for transfer, transferred and then assimilated. The paper concludes with comments about the use of the framework and directions for future research.

Keywords: Knowledge transfer, universities, industry, tacit knowledge

1 Purpose

Companies in business and commerce need innovation to develop and compete. One source of innovation is by adopting ideas and techniques that are developed or simply better understood in institutions such as universities, other research bodies or higher education institutions (HEI). This exhibited itself in the first part of this century with ‘collaborative manufacturing enterprises’ joining other organisations, in networks where continuous improvement and incremental innovation practices could be developed and shared[1]. In this decade the focus has broadened to Open Innovation, which dispenses with the “old” linear model of innovation and promotes “*the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and to expand the markets for external use of innovation, respectively*”[2]. Based in a university that works closely with industrial partners, the researchers were keen to understand the process of knowledge transfer so that it could be improved, but found little substantiated theory on managing knowledge flows.

This paper presents a practical framework that focuses on the act of transferring knowledge from one party to another and is set in the context of knowledge transfer activity between higher education and industry. The framework is structured around the well-known categories of tacit and explicit knowledge [3] where implicit knowledge exists between tacit and explicit forms[4]. The framework has practical relevance to managers and participants in knowledge transfer projects and can be used in the planning stages of a knowledge transfer; can be used to analyse actions during the activity of transferring knowledge and can be used to review a completed knowledge transfer.

To explore if this framework worked in practice semi-structured, face-to-face interviews with expert respondents from recently completed knowledge transfer projects (25 interviews representing 19 completed projects) were undertaken. This work builds on a definitive list of the channels of knowledge transfer, developed by Alexander & Childe [5].

2 Context

The drive to gain competitive advantage fuels businesses development worldwide. According to Grant [6] knowledge has become the most important of a firm's resources and authors such as Teece, Drucker, Cohen all talk of the importance of achieving a knowledge society. Competitive Advantage is seen to come from the transfer of external or new knowledge into a company as an important source of Innovation [7]. Universities are important sources of knowledge and a number have shifted their strategy from only pursuing research and teaching students to position research and knowledge transfer activities as their first priority. If companies are able to gain competitive advantage from working with universities then effective ways of transferring knowledge are required [8]. Chilton & Bloodgood [9 p.76] state "*a stream of research needs to investigate moving tacit knowledge directly into outcomes*". Further Meier states there is a "*lack of research on which knowledge management practices are most useful in order to transfer different types of knowledge*" [10 p.17] . By understanding the performance of the different channels of knowledge transfer using the framework, the flows of knowledge between the two organisations can be considered and actions can be undertaken to improve the likelihood of the success of any particular knowledge transfer.

For industry to be able to exploit knowledge, our previous work has shown that that knowledge is needed to support action. We therefore take the view in this study that for useful exploitation, a successful transfer of knowledge would be one that resulted in the transfer of tacit knowledge [5].

2.1 Typologies of Knowledge

Beckman [11 p.23] defines knowledge as "*reasoning about information and data to actively enable performance, problem solving, decision making, learning and teaching*". Polanyi's definition of knowledge [3] distinguishes between tacit or

theoretical knowledge and explicit, recognised or scientific knowledge. Grant [6] states that tacit knowledge is “knowing-how” and explicit knowledge “knowing-about”.

Companies are collectives of humans and to some extent they learn accordingly. If we consider Piaget’s theory of child learning [12], as a child gains new experiences or learns new things they reflect these back to existing experiences in order to be able to comprehend and understand them. This is not only a reflection of how children learn, adults use the same method of reflection and assimilation, using like experiences to process new information and to turn it into tacit knowledge. This was identified by Scribner [13] whilst studying the collective learning of workers employed within a dairy. It is this cognitive absorption that occurs within the transfer of explicit knowledge to tacit knowledge (according to Polanyi in 1966 and later Scribner in 1985 amongst others) and at this point of cognition that the knowledge takes on the “ability to act”.

An argument can be made that explicit knowledge, in the form of instruction manuals, is an explicit representation of tacit knowledge and as long as the instructions are clear enough to follow, explicit knowledge should provide an ability to act. From that point of view, the ability to act is not solely dependent upon tacit knowledge. However Scribner etc argue that the instructions replicated in a manual (or articulated in process and procedures for dairy workers) are explicit and still require the cognitive absorption, assimilation with like experiences and reflection in order for them to be used to create an ability to act – which is the development of tacit knowledge. Scribner offers that, in developing the tacit knowledge, employees often then abandon explicit instructions and explicit knowledge, in favour of improved routines and personalised actions.

The literature suggests a spectrum of views, ranging from those that believe that knowledge is seated in the knower and therefore cannot be transferred at all, and those that believe that knowledge can be externalised and therefore transferred. We take the view that tacit knowledge can be transferred but that this is hard to achieve. It subscribes to the view of Chilton & Bloodgood who suggest a continuum in which fully tacit knowledge is completely embedded and fully explicit knowledge is entirely codified and that the remainder of the knowledge in the world lies somewhere upon this continuum. This realises that tacit knowledge can be transferred, but this transferrable knowledge is not located at the extreme, “tacit pole”. It also recognises that explicit knowledge can include aspects of know-how (or tacit knowledge) in relationship to an instructional manual and this perspective is not located at the extent of the “explicit pole” bounding the continuum.

This representation of a tacit-explicit knowledge continuum is criticised by Tsoukas [14] and Gourlay [15]. They argue that the interpretation of the tacit to explicit continuum or at least the one presented in the ‘SECI’ process developed by Nonaka & Takeuchi [16] is incorrect and does not respect the original explanations of tacit and

explicit knowledge presented by Polanyi [3]. They explain that instead of tacit knowledge existing and then being converted, through the process of socialisation, into explicit knowledge, the two types of knowledge exist simultaneously and represent “two sides of a coin” instead of two ends of a continuum. To illustrate this they suggest that there are two sort of awareness and that each state of awareness relates to a type of knowledge. They use an example of driving a nail. The person holding the hammer focuses on the head of the hammer and the head of the nail – this is their focal awareness. The person hammering is not consciously aware of how the hammer feels within their hand or how their muscles feel as they bring down the head of the hammer – this is their subsidiary awareness. Tsoukas [14] likens focal awareness to explicit knowledge and tacit knowledge to subsidiary awareness. He argues that as tacit knowledge is within one’s subsidiary awareness it cannot be separated from the person and is therefore intangible. This perspective can only promote the transfer of knowledge via personnel movement.

Tsoukas [14] and Gourlay [15] however are arguing that the conversion between tacit and explicit knowledge, explained in the SECI process of knowledge creation, does not actually create new knowledge and they do not mention the transfer of knowledge. The second example provided by Tsoukas [14] may help to understanding how tacit knowledge can be transferred in this context. When examining a cavity, a dentist’s primary focus is on the pointed probe in their hand and the view they can obtain using the mirror – the subsidiary awareness is the feel of the probe in their hand and the feedback they get as they move the probe into the cavity etc. If the dentist becomes unable to see the end of the probe, nor view the inside of the cavity, their focus shifts to their subsidiary awareness - to the feel of the probe in their hand and the physical resistance presented by the cavity. This is built through reference to experience and suggests that differing levels of tacit and explicit knowledge can exist, depending on the situation. The continuum explained above recognises the polarised position of transfer of pure tacit and this would reflect a sole focus on subsidiary awareness. Likewise it recognises the transfer of purely explicit knowledge, which would represent the transfer of only focal awareness. The continuum suggests that there are a range of intermediate states where tacit knowledge can transfer to some extent, and this would represent a blend of focal awareness and subsidiary awareness.

A revised continuum is therefore presented in Figure 1.

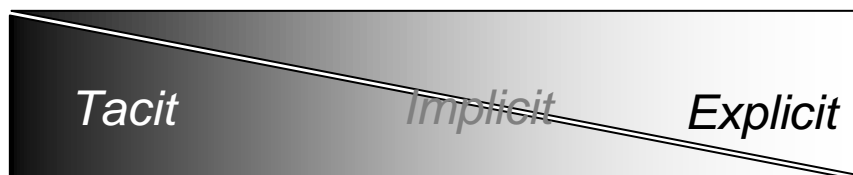


Fig. 1. The Tacit to Explicit Continuum

At the left-hand end the knowledge is tacit and cannot be transferred as it is entirely within the knower. This represents a predominance of subsidiary awareness – like the dentist who is operating ‘blind’. The right-hand end is explicit, fully codified knowledge and with a dominance of focal awareness, with little realisation of tacit knowledge and subsidiary awareness.

Liebowitz & Beckman [17] introduce a third property of knowledge that they suggest lies between tacit and explicit, that of ‘implicit’ knowledge.

According to Beckman (17 p.p. 1-4):

- Tacit (residing in human mind, or organisations) is accessible indirectly with difficulty (through knowledge elicitation and observation of behaviour);
- Implicit (residing in human mind or organisation) is accessible through querying and discussion (but informal knowledge must be first located and then communicated);
- Explicit (residing in document or computer) is readily accessible, as well as documented into formal knowledge sources that are often well organised.

The inclusion of implicit knowledge may help to understand the stages of a knowledge transfer. In considering actual knowledge transfers and therefore exploring if this model works in practice, the inclusion of the term implicit knowledge may make it easier to recognise the transition between tacit and explicit.

In this paper, Tacit Knowledge is defined as “knowledge that is resultant from both the cognition of information and the interaction with experience and encompasses the ability to act” [18] while “explicit knowledge can be expressed in words and numbers and shared in the form of data, scientific formulae, specifications and manuals” [19]. Implicit knowledge exists between these categories (that represent the poles on a continuum) and refers to the start of codification of tacit knowledge or the refocus toward subsidiary focus, where the knowledge starts to become structured or organised [4]. The framework proposed within this paper draws on these definitions.

2.2 A Framework for Knowledge Transfer.

Whilst it is possible in some cases to transfer knowledge at the tacit level, from one person’s deep understanding and ability direct to another’s, this is likely to take considerable time (for example apprenticeships) and is rather limited as a source of innovation. Alternative channels facilitate transfer at different levels on the continuum between tacit and explicit. For example, as a member of staff from a university prepares to transfer knowledge, they use their intellectual ability organise their knowledge on a subject (making it implicit) and then they codify their knowledge into an explicit state - language, information, data or text that can be used

for the transfer. The transfer occurs with the participation of the recipient, a member of the commercial organisation, who must then learn and understand the new knowledge in the context of the organisation and develop the experience to apply the knowledge in action. This processing is shown in Fig. 1. (As knowledge transfer is a two directional activity, there is also a transfer occurring in the reverse direction, although for simplicity this reciprocity is not shown in Fig.2.)

One route to enable knowledge transfer, for which there is extensive agreement, involves codification of tacit knowledge prior to transfer. For example, as an instructor prepares to teach a class they begin to assemble the knowledge they possess on the teaching subject. This is the translation or codification stage where tacit knowledge retained within the instructor is first made implicit (organised, structured and ready to transfer) and then fully codified (in words, language, demonstration, images etc) as it is transferred [16 p. 9] This is an example of teaching or education and not knowledge transfer, but is relevant, to explain how knowledge is codified in a simplistic way.

Explicit knowledge could manifest in the form of data or text. The working definition of explicit knowledge above refers to “words and numbers and shared in the form of data, scientific formulae, specifications and manuals”.

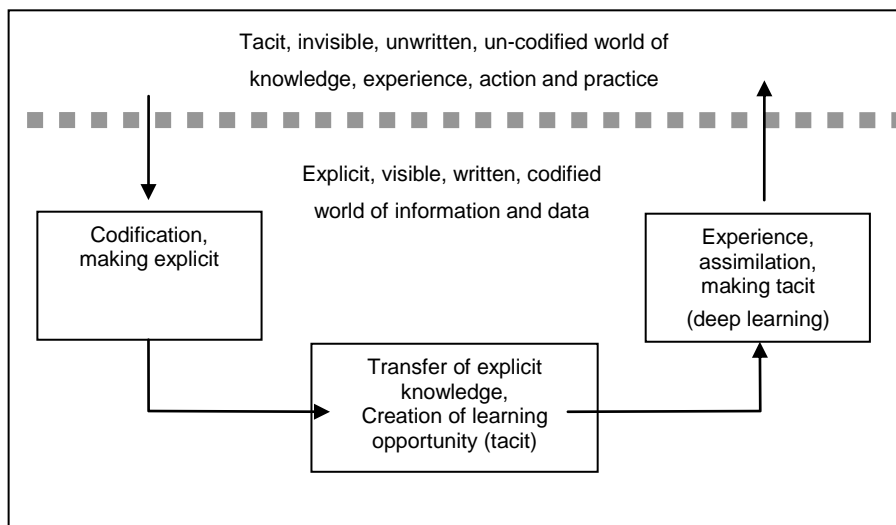


Fig. 2. Pre-transfer and post-transfer processing of knowledge

The Information Systems research of Checkland & Howell [20] develops a routine or set of steps to translate data into knowledge. Whilst this has ‘knowledge-based management’ origins, as opposed to ‘strategic knowledge management’, the theory may still be relevant. Each step (or process) relates to the capture of data, being pure figures or text and the subsequent undertaking of *capta*, the act of placing relevance to

the data to make it information. The theory suggests data with *capta* becomes information and that with the addition of cognitive structures and some form of longevity this becomes knowledge. This progression from data through to knowledge could be considered to be similar, in as much as there is linearity in the process of conversion, to the progression from explicit to tacit as explained by Sveiby [21]. The key step in Sveiby's suggested process that converts explicit into tacit knowledge is, for one thing, the addition of the "ability to act" or to "apply it". He goes on to argue that each time a codification or translation occurs, and the parties begin to transfer explicit information, a potential exists to lose a component of that knowledge through the interpretation stage. The act of codification between tacit and explicit can be represented on a linear scale (similar to the progression between data and knowledge referred to in 'knowledge-based management') as can the cognition (or interpretation) that occurs as the knowledge is re-codified by the recipient, to add the ability to act / application. There is a significant amount of research that considers the intellectual processes that occur to embed this ability to act. These include the referencing of new knowledge to other personally embedded experiences that are similar that allow the cognition and embedding of this knowledge [22]. Another process referred to is the repetition of 'like actions' that lead to individuals being able to digest and therefore vary their work patterns to accommodate local efficiencies in cognitive processes [13].

All of the perspectives considered above suggest that the transfer of knowledge is complex. A way to reflect the perspectives of the authors above, who are trying to create explanation around the act of transferring knowledge, whilst trying to define the properties of knowledge, is to create a way to visualise the subject. Epp & Price [23] suggest that a "sensitising framework" could be one way to enable people to visualise and comprehend an intangible. Wacker [24] also suggests that some form of a framework or mental model is a good way of visualising theory.

A framework for review has therefore been developed to aid practitioners and people who will become involved in knowledge transfer to understand how the properties of knowledge can change during and transfer of knowledge. This is shown in Figure 3.

For simplicity the framework takes only two stakeholders into account; the University and the Company and does not consider the additional stakeholders promoted by Etzkowitz [25] and Stevens & Bagby [26]. This is because normally the third stakeholder (the government) and the fourth stakeholder (society) do not directly become engaged in the actual process of transferring knowledge.

The framework portrays the transfer of knowledge between Universities and Industry or commercial organisations, firstly in the form of tacit-to-tacit knowledge shown at the top of the framework and toward the lower half in the form of explicit exchange of knowledge, importantly in two directions from the university to the company and reciprocally between the company and the university. According to Polanyi [3] the

transfer of tacit knowledge is hard to achieve; this is represented by the size of the transfer arrows in the model, but no scalable relationship is inferred by the relative size of the arrows.

The lateral arrows represent the properties of knowledge and show a shift in the types of knowledge progressing from tacit (at the top), through implicit to explicit (at the bottom). The left hand arrow relates to codification and cognition as does the right hand arrow. The top of each arrow represents high levels of tacit knowledge, resulting from experiences and education and laden with the ability to act. The bottom represents a dominance of explicit knowledge. This continuum exists between the poles of “entirely tacit” knowledge and “entirely explicit” knowledge, however there is never a state where either no explicit knowledge exists, and vice versa. This corresponds to the view of Tsoukas [14] and Gourlay [15].

Real examples, where knowledge was transferred at the tacit level, and also those where the route from tacit-to-tacit is via codification, explicit transfer and understanding or assimilation were used to validate this framework. The purpose of this research is to create a guideline that identifies which channel is likely to transfer tacit knowledge most effectively. This is achieved by referencing the work of authors such as Schmoch *et al* [27], and Schartinger *et al* [8] and then triangulating their findings against real examples of typical knowledge transfer projects (to understand the transfer of knowledge within each type of channel) and reflecting on the framework. The results can be used to influence the choice of knowledge channel for both industrial managers and academic institutions.

3 Methodology

A detailed research protocol was established as part of this strategic knowledge management research – a research field that unlike its sibling “Knowledge-based Management (an evolution of information systems), is still in its infancy and lacks robust, empirically tested theory. In relation to operations research, and the three dominant systems perspectives (hard, soft and critical), in general terms a “hard systems perspective” employs only a positivist approach to study “objective data” (which can be likened to seeking only explicit knowledge) whereas, a “soft” systems perspective however treats knowledge in a more phenomenological way as being “*tacit, generated and consumed in social action... and it is assumed that this knowledge is Innovation*” ([28] p. 388). By combining methodologies into a dualist, social constructivist approach and seeking mode 2 knowledge creation [29], a robust three-step data collection protocol was established around participant enquiry and participant interaction.

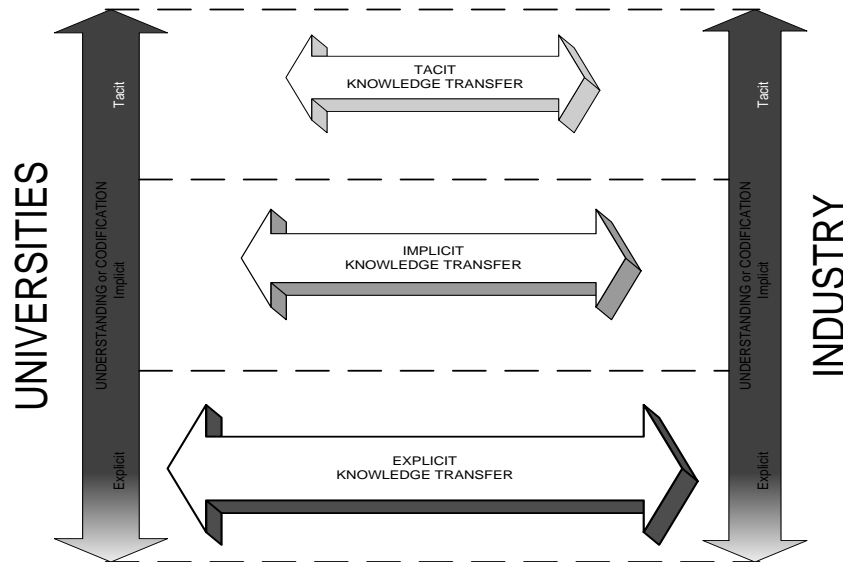


Fig. 3. The Assessment Framework

The research instrument was derived (within step 1) by reference to a Delphi-style expert panel, made up of 10 'innovation-focussed' policy executives and subsequently posing a broad-range question to a community of practice. Step 2 involved data collection using semi-structured interviews lasting 90 minutes, in certain cases followed by a second 60 minute interview, undertaken after a period of interviewer reflection. Each interview was transcribed and returned to the subject for approval before being summarized in a partially-coded in-case tabulated summary. To ensure that the data collected was representative a sample size and selection criteria were developed for the second and third parts of the study. In total 19 completed projects were chosen for review in 25 interviews, not all with an operational management focus, but taken pan-sector and across a range of innovation disciplines. Reliability, validity and generalisability were expressly considered as was the role of experimental control for this study, which looks to build theory, before subjecting it to deductive-style testing within further research.

4 Findings

The knowledge transfer projects that were studied included the development of a spin-out company exploiting engineering-based research in software analysis and three patents involving a range of research, from novel techniques in spectroscopy to a bio-science application.

In the 19 interviews undertaken in step 2, all respondents acknowledged that the framework did reflect the way that knowledge transfer occurred within their projects. The 6 interviews taken in two further case studies (step 3) representing triangulated stakeholder opinions agreed that the framework typically represented how knowledge transferred as well. A summary of the interviews and results is shown in Table 1.

A good example of a response that affirmed the framework in detail is a “joint supervision” case study (TRMU) focussed on the development of materials for a museum of local culture. The respondent stated that the transfer took place over a long period and they felt that tacit knowledge transferred at the outset as face-to-face interviews and subsequent transcripts were developed. This led to the development of explicit material that could then be displayed in the form of teaching materials in local schools. Further explicit material were developed in the form of a booklet that was circulated within the local community and also uploaded to the internet.

Analysing the content of the response and referring it back to the framework it could be suggested that the transfer of tacit-to-tacit knowledge via face-to-face communication was one act of knowledge transfer, between interviewer and interviewee. In relation to the preparation of the media and dissemination in the form of a booklet etc, this could be considered as a second act of knowledge transfer and be identified as tacit-to-explicit prior to transfer, however this is not true knowledge transfer as this element of the project is only one-directional. This project does relate back to the framework and the responses have confirmed the aim of the framework, which is to enable the subject to consider the implications of transferring different types of knowledge.

In multiple interviews from a case in contract research and consultancy (RDEP) the second interviewer states the “flows reflect the model but there was a mix of tacit and explicit in varying proportions during the project. There was an exchange of tacit at the beginning. As the project became more defined, with more knowledge then the University could provide more focussed knowledge into the products, so it started off with having mostly tacit knowledge, with some explicit and as the project moved on the knowledge became more explicit”. This reflected a deeper response than some of the interview candidates had made, when reviewing the framework.

The other respondent from the same project stated “the framework is OK – I have never thought of it like that I guess, we mostly transfer [knowledge] across the big arrow at the bottom as companies can’t wait or can’t afford the tacit bit”. The third respondent from this case stated the “first process is the transfer of tacit knowledge to explicit knowledge from industry to university, second is the transfer of the tacit knowledge from the university staff into explicit knowledge in the product and the third is the transfer of our explicit knowledge to explicit knowledge for the industrial partner. Also each transferred tacit knowledge to tacit knowledge at the beginning, then tacit knowledge was transferred to explicit in the form of the product design specification and then we transferred explicit to explicit knowledge in the prototype”.

| Interview Number | Interview Code | Knowledge Transfer Channel (number) | Acknowledgement | Affirmed | |
|----------------------------|----------------|-------------------------------------|-----------------|-----------|------------------|
| | | | | in detail | with suggestions |
| KEY RESPONDERS | | | | | |
| N/A | N/A | Graduate Employment | | N/A | |
| 1 | UEME | Joint Conference | | X | |
| 2 | ATT1 | Spin Out (1) | | X | |
| 3 | ICO3 | Spin Out (2) | | X | |
| 4 | SIMP | Spin out (3) | | X | |
| 5 | AEBS | Professional Journal | | | X |
| 6 | EDSN | Network 1 | | | X |
| 7 | 3DAC | Joint Supervision 1 | X | | |
| 8 | TRMU | Joint Supervision 2 | | X | |
| N/A | N/A | Training & CPD | | N/A | |
| 9 | PATC | Collaborative Research | | X | |
| 10 | KELL | Contract Research & Consultancy (1) | | X | |
| N/A | N/A | Shared Facilities | | N/A | |
| 11 | SYNG | Patent 1 | | X | |
| 12 | MALA | Patent 2 | X | | |
| 13 | ATT3 | Patent 3 | | X | |
| 14 | ARGA | Joint Venture 1 | X | | |
| MULTIPLE RESPONDERS | | | | | |
| 15 | QINE | Joint Venture 2 | | X | |
| 16 | QINE (2) | | X | | |
| 17 | RDEP (1) | Contract Research & Consultancy (2) | | | X |
| 18 | RDEP (2) | | | X | |
| 19 | RDEP (3) | | | X | |

Table 1. Summary of results

During the interview response above the design engineer traces their finger across the framework picture to correspond with the flows that they are verbalising.

In the third patent project (ATT3) the respondent indicates that “there was definitely a flow of information from tacit to explicit, but the whole model was definitely skewed to the left-hand side; any release of knowledge to industry was done in a stage managed way”. In patent 2 (MALA) the respondent felt that “the whole model [framework] was going on, but there was probably more explicit knowledge” and in patent 1 (SYNG) the respondent agreed “it is basically what happened, we have tacit knowledge about fungi and fungicides that we used to test the patent from [name] and it proved to work and we then presented the work in explicit form to the company, the company has taken up the knowledge and it will become tacit with them”.

Contract research & consultancy 1 (KELL) suggested the framework “reflects the study. At the beginning the children had tacit knowledge which was shared with the university staff; the university staff also have some tacit knowledge. The children’s knowledge in terms of diaries, measurements etc was codified, understood and then the data was collected and written down in the form of a report. This knowledge is then passed to the company”.

Three of the respondents also suggested improvements to the framework. The respondent that had been interviewed because of their experience of networks to transfer knowledge (EDSN) felt that the framework reflected knowledge transfer in networks but to differing extents and this related to each particular network. The respondent went on to suggest a modification to the framework, so that instead of pure transfer of knowledge occurring on the x-axis (horizontally) a time line could be superimposed to show how the transfer of tacit knowledge changed over the duration of the knowledge transfer.

The academic responding from their experiences of consultancy (RDEP) affirmed the model represented their particular knowledge transfer “almost”. They then described key stages of their particular transfer with reference to steps within their project. The first step was explained as being the translation of tacit knowledge into explicit knowledge as the industrial partner defined the problems and sent documents relating to context and needs – a brief or scope of works. The second step was explained as the University translating the explicit knowledge within the brief into tacit knowledge (to develop a proposal of what they intended to undertake). The next step was the codification of the tacit knowledge into a material artefact (where drawings were prepared, further codified into the software and printed on an additive layer rapid prototyping machine to create the end product) in the form of a prototype and finally, the transfer of explicit information between the parties as the prototype and report are exchanged to complete the project.

The professor and co-author responding in respect to the joint academic publications (AEBS) stated “on a simplistic level I can understand how this model applies to the project but I see knowledge transfer as more circular and fluid. I think the transfer was not as linear as the model implies; knowledge can happen on various different levels with more or less tacit and explicit knowledge being exchanged at one time, which is why I think the model has to be put into context. It needs to take into consideration time. I can see how a circular model of knowledge transfer can happen in an hour and can also take several months. Also I think that generally the model has to be put into context in the problem situation and that it is important to define outcomes”. The comment relating to the simplistic level is important as this framework can only really work at a high level where management guidelines and review instruments are often most effective - they operate best at a simplistic level and taken too literally can be misleading.

It is important to understand that the framework has a broad range of applications – it can be used to take a “snapshot” of how knowledge is being transferred at a particular point in time, but it can also be used in planning, to create an ambition of transferring mostly tacit knowledge or it can be used in reflection to consider how knowledge flowed in a project, perhaps as part of a post project review process or lessons-realised exercise.

In summary the responses received from the interviews taken from completed knowledge transfer projects suggest that the framework is a helpful map to enable interviewees to reflect on their particular the study has knowledge transfer projects. We have demonstrated that the framework stimulates the thoughts of professionals focussed around what types of knowledge flow between a company and a higher education. All of the respondents were able to relate this framework to their real life examples of completed knowledge transfer projects that were promoted by their respective companies, universities or government organisations as successful examples. Each respondent either acknowledged the pertinence of, or affirmed in detail or with suggestions how the framework could be related to their particular project. The only exception to this arose during the interview with the company respondent representing a project to develop a 3-dimensional CAD facility within a traditional boat building firm. When asked if the framework reflected the flow of knowledge in the project the respondent replied “No, the knowledge transfer was the reverse of this model” however there were two interesting notes made by the interviewer relating to this statement. These were that the subject was unable to articulate how flows could act in reverse and that the subject could not elaborate around the framework and became dismissive”. The most likely answer to this, is that the respondent had failed to grasp the two-directional nature of the framework (and was referring to the reverse flow as right to left and not left to right) or that the term reverse relates to there being only explicit knowledge in the heads of the project participants, which then became tacit as the project progressed. It would seem that without reference to this respondent further a clear explanation cannot be offered, however it does seem that the framework has still achieved what it set out to do,

which was to make the respondent consider the way in which knowledge transferred in their project.

In obtaining more than 12 responses this research proposes that the framework could form the basis of a useful construct, which when applied to a phenomenon (where company and academic personnel promote the success of a knowledge transfer without reference to objective measures or detailed comparative analysis), improves the understanding of what is occurring within the projects.

The responses (including some that looked to try to improve the way the framework represented knowledge transfer) demonstrated to the researchers that the framework has achieved what it set out to do. A summary of the results can be seen in Table 1. It stimulates professionals' thought into what types of knowledge flow between a company and a higher education and allows people to visualise knowledge (which is often overlooked due to the difficulty in visualising it). All of the respondents were able to relate this framework to their real life experience of knowledge transfer projects undertaken by their respective companies, universities or government organisations. Each respondent either acknowledged the pertinence of the framework, or affirmed its usefulness in detail, or affirmed while adding suggestions how the framework could be related to their particular project.

5 Practical Application of the Framework

The framework and the understanding gained from the knowledge transfer cases will lead to a tool that can be applied to stimulate innovation by allowing managers to select the most appropriate channels for transferring knowledge into companies from universities, using such channels as staff secondment, jointly supervised projects, consultancy, contract research etc. The research also allows universities to configure their offerings to industry in order to tailor their activities to offer the maximum benefit according to the situation and the type of knowledge to be transferred.

As a particular example studied, a process-based outsourcing service company undertook a two year joint-supervision project (within a UK-specific grant funded scheme entitled Knowledge Transfer Partnership – KTP). The aim of the project was two fold: to review the contract and order fulfilment capability within the company (which at the outset turned-over around £500k per annum and employed 12 staff working across shop-floor and IT-based service provision) and undertake an Activity Based Costing appraisal to highlight the contracts with the greatest yield and to redesign the order fulfilment processes to greater increase the contract yield, whilst downscaling the sales and marketing activity for poorly performing contracts.

As a result of the project the company reported an increase in net profits of more than £300k which they attributed to improved operational efficiency (28%), targeting only

profitable contracts (27%), longer duration contracts (33%) and increased production capacity (27%).

When questioned the company respondents stated “*The people who fund the project [in reference to the grant body] want explicit knowledge because they want to be able to measure it. Some explicit knowledge is needed, but the essence of the project, and its greatest benefit, is the transfer of tacit knowledge*”. Whilst reflecting on the framework the university respondent stated that “*most of [the knowledge transferred] is in the implicit stage and it happens on a continuum*”. The company respondent, in this case the Managing Director, stated “*[the knowledge flows] were definitely happening but at different rates and in numerous forms, some of which is still going on [the interview took place 6 months after project completion] and I would say that we are at the implicit stage for embedding (on right-hand axis of the framework)*”.

6 Conclusions and future research

The conclusion for this research is that by referencing experts in this area and by studying the outcomes of participation in collaborative projects, transferring knowledge back and forth between industry and higher education, we have developed a useful and practical visualisation framework. Within an immature research landscape, where main contributors in this area relate to the barriers to; benefits from and motivations for knowledge transfer, we have contributed to theory. By focussing on certain attributes or properties of knowledge the framework can be used to aid in planning a knowledge transfer activity and visualising how knowledge might flow during the project. This will in-turn affect decisions on governance (where a partnering style of governance can lead to more tacit knowledge being transferred[30]), geographic location of the knowledge partner (in relation to the ability to hold face to face meetings [5]) amongst a number of other factors.

Future research in the this area will focus on balancing the extensive qualitative data collected within this study with more objective measurements of performance, again taken across completed knowledge transfer project as the second, more deductive phase of theory development (according to [31]).

In terms of further application of this research, a study developing this framework into a set of management guidelines for policy makers, managers and participants within knowledge transfer projects has already been undertaken and the results are awaiting publication. It is planned to extend these guidelines further by incorporating them into a policy decision-making tool based on innovation management capability and innovation channel suitability.

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