

Towards a framework for transferring technology knowledge between facilities

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Revised July 2012

Structured abstract

Purpose - The transfer of technical know-how is now recognised as an essential component in the globalised expansion of multinational companies. As these companies offshore or outsource their operations the success of the new facility can depend upon the ability to convey both tacit and explicit knowledge willingly during all phases of the transfer. There is a lack of clarity in current literature on the success factors for effective transfer of knowledge on production parts transfer and an absence of frameworks. This purpose of the research reported in this paper is to examine documented success factors and propose an integrated framework.

Design/methodology/approach – Peer reviewed literature was used to establish dominant themes on knowledge-sharing from which interview and survey were designed and undertaken to establish motivating factors.

Findings - Five key themes required for successful knowledge transfer were established for moving parts to new production facilities: willingness to share information, willingness to receive information, explicit knowledge transfer, tacit knowledge transfer and verification. These were then assembled into a Transfer of Technical Intellect framework for knowledge transfer to new facilities.

Research limitations/implications - The research draws from the experience of practitioners across multiple parts transfers rather than examining a specific transfer. This work brings research not previously brought together. It draws from the literature and a significant survey of a large multi-site engineering company and future work needs to be carried out to examine the generalisability of the work.

Practical implications – The proposed framework guides the tacit as well as explicit transfer of technical knowledge of production parts between facilities.

Originality/value – The research identifies the key themes and motivating factors for transferring tacit product knowledge to another organisation.

Keywords: tacit knowledge transfer, parts outsourcing, facility transfer, technical know-how

Article classification: research paper

Towards a framework for transferring technology knowledge between facilities

Introduction

Increasingly as multinational companies expand their manufacturing capability, the requirement to transfer knowledge successfully has become a critical factor. The decision to outsource or offshore parts from a production facility to a different location in the world is commonplace. Attached to this globalisation expansion are not just the infrastructure and machinery challenges, but how a company transfers the vital technical knowledge between the plants. Such technical knowledge refers to how to produce goods including the how to control the process, the key tasks, skills, competence, etc. (Bohn, 1994; Johnson et al. 2002).

As a consequence of these new opportunities research is being applied to the subject of knowledge transfer. Inkpen (2008) discusses the subject of organisational knowledge transfer. Dyer and Nobeoka (2000) researched specifically how Toyota shares knowledge. Pil and MacDuffie (1999) link knowledge transfer to the survival of transplants. Štrach and Everett (2006) researched how Japanese multinational companies transfer knowledge to create a concept model of knowledge transfer. Gupta and Govindarajan (2000) propose an overarching theoretical framework pertaining to intracorporate knowledge transfers within multinational companies and then test this theory. In all cases they declare how important knowledge transfer is to the successful worldwide growth of a multinational company and examine the key factors required for effective knowledge transfer.

The ability and reasons for knowledge transfer are well documented (Agarwal et al, 2004). The skill in relocating a facility or outsourcing is the capture and transfer of the unknown, tacit knowledge that individuals hold that are essential to the successful implementation of a sister facility or transfer of a production process.

This paper captures the understanding of how to transfer the technical knowledge from individuals to a new global facility. The research was driven by the authors' experience of problems with successful parts transfers between facilities and the lack of a coherent structure of how to conduct this in the literature. The approach adopted was to review the literature on outsourcing, offshoring, spin-offs, franchises as well as facility moves in order to gain a comprehensive picture of knowledge transfer. Key authors (Agarwal, 2004; Cheng et al., 2010; Chua & Pan, 2008; Szulanski & Jensen, 2006) report research to address some of the issues experienced but encompassing frameworks are not available. Hence, the information acquired from this process was then utilised to develop interview and survey instruments to capture primary data from experienced personnel in the field of facility transfers. Finally, the outcomes were used to develop a Transfer of Technical Intellect framework for moving parts to new facilities.

Methodology

The aim of this research was to create a framework for the transfer of technical know-how. Starting with literature review to capture theories and procedures, experienced facility transfer professionals were interviewed to confirm and adapt the outcomes of the literature search. The result of this process was applied to a survey designed to probe the concepts found in the literature against the actual experiences of a large technical community. From these stages, the Transfer of Technical Intellect framework was developed.

Given the large amount of general but not fully integrated work in this field the work was deductive, seeking to consolidate and confirm knowledge and combine it into a single framework. With literature as the most appropriate starting point for deductive research (Christensen and Sundahl, 2001) in order to establish knowledge in this field to check against a sample of practitioners to ascertain if the literature had a significant lag with practice and whether it was representative of practice. A closed, large scale, focused questionnaire was an appropriate form of empirical data capture.

The literature review consisted of an analysis of journals, articles and books on the subject of knowledge transfer. The two main search vehicles used in this research were Scopus and ABI/Inform. The purpose of literature review was to identify completed work and find gaps in existing research (Hart, 2001). There was an abundance of literature available against the basic subject of knowledge transfer. However once this field was narrowed to knowledge transfer and specific aspects of new facilities, outsourcing and offshoring it soon became apparent that there is little literature published on this subject. In addition to key word searches, the tables of contents of selected journals were searched as well as retrieving the references contained within the papers. Selection of the papers located by all searched methods was based on examination of abstracts and, if appropriate, then conclusions and then main text. The keyword searches were refined and repeated during this process.

The purpose of the interviews was to gain firsthand knowledge from experienced facility transfer programme managers. A semi-structured interview format was adopted as it was anticipated that the interview would not have a common sequence to questioning (Robson, 2002) as interviewees would provide their experience through projects and stories. Common open questions were asked in face-to-face and telephone interviews. The five interviewees had a more than 18 different facility transfers between them. Responses were recorded against the posed questions and new topics should they emerge during interview.

Using the advantages speed and efficiency of surveys (Zikmund, 1999), a questionnaire was then constructed to expand on the literature review and interviews by tailoring specific questions to staff of mainly engineer and engineering manager grade working in the aerospace industry, hence taking a representative sample of a known population (Robson, 2002). The purpose of the survey was to ascertain the key barriers to the transfer of know-how and how these might be overcome. The results of the survey were assembled with the prior research to construct a framework for the transfer of technical know-how.

Literature

This research investigated a variety of mechanisms for the expansion or relocation of companies and how they transfer knowledge through these activities. Additionally it addressed the broader knowledge transfer theme.

The smooth implementation of outsourcing has received insufficient research attention and there is a need to better understand the process of knowledge transfer (Mohiuddin, 2011). The various modes of global knowledge transfer reviewed were franchises (Szulanski & Jensen, 2006), spin offs (Agarwal et al, 2004), offshoring (Slepniov & Waehrens, 2008; Chua & Pan, 2008), outsourcing (Mikkola, 2003) and facility moves (Cheng et al, 2010). From the research five strong themes emerged as paramount to the successful transfer of technical know-how. The following themes are common across the literature but have not been captured together with equal importance for knowledge transfer:

- Willingness to share information
- Willingness to receive information
- Explicit knowledge transfer
- Tacit knowledge transfer
- Verification

Willingness to Share Information

While capacity to transfer is the requisite condition for knowledge transfer, willingness to transfer determines the extent to which knowledge will be contributed (Wang et al, 2004). Therefore a good relationship between the transmitting facility and the receiving facility is essential. Dudley (2006) recognised the importance of relationships in transfers, commenting that much time and effort is spent on the science and technology behind transfers, but not enough on the relationships between partners. He concludes both facets are essential to a smooth transition.

Bresman et al (1999) noted that individuals will only participate willingly in knowledge exchange once they share a sense of identity or belonging with their colleagues, and the transfer of technological know-how is facilitated by communication, visits and meetings (Kohlbacher & Krähe, 2007).

Relationship building, and specifically trust, is required to obtain a willingness to share. If individuals do not trust others then they will not disclose information. The level of trust that exists between the organisation, its subunits, and its employees greatly influences the amount of knowledge that flows between individuals and from individuals into the firm's databases, best practices archives and other records (De Long & Fahey, 2000; Westner & Strahringer, 2010). Dudley (2006) confirms that when trust is cultivated, partners have a greater sense of comfort in working towards success.

The motivation to share information is important. If a person has no reason to share data, then probably they will not. Gupta & Govindarajan (2000) studied in depth the motivation of the knowledge source. They anticipate that factors which would enhance the motivational disposition of the source unit to share its knowledge with other units within the MNC are likely to counterbalance any hoarding tendencies and thereby have a positive impact on the magnitude of knowledge outflows. This is recognised by Overby (2004) as well as the negative motivational impact quoting a CIO "more often, critical systems knowledge resides in the heads of people who stand to lose their jobs when the offshore team takes over. Coaxing employees to train their replacements is a no-win situation; you're basically asking them to dig their graves before you shoot them".

Closely linked with motivation is reward. Many people want to know what is in it for them, what is their incentive to share knowledge. Minbaeva et al (2003) acknowledge this in their work on knowledge transfer and absorptive capacity, "Performance-based compensation, merit-based promotion and internal communication are positively related to employee motivation". Thurm (2006) discloses how some firms offer rewards, such as cash or t-shirts for seeding knowledge databases, to entice the facilitation of knowledge transfer.

Finally good leadership can improve the willingness to share and challenge barriers to transmitting knowledge between workers and managers. Goldhaber (1993) noted four key tendencies of factory workers to (1) distort information upward in a manner that pleases their superiors; (2) tell their superiors what they want to know; (3) tell their superiors what they want to hear; and (4) tell their superiors

information that reflects favourably on themselves and/or does not reflect negatively on themselves. Reige & Zulpo (2007) conclude if factory workers feel intimidated by their superior, they tend to selectively withhold information that may be important but reflect badly on themselves, make superiors angry, or create problems for the superior. It is therefore imperative that good leadership prevents these barriers from arising.

Willingness to Receive Information

Not only is the willingness to share information crucial to knowledge flow, but the willingness of the receiver to acquire the knowledge is just as vital. This absorptive capacity (Gupta & Govindarajan, 2000) is the ability to recognise the value of new information, assimilate it, and apply it to commercial ends (Cohen and Levinthal, 1990). Ability and motivation must both be present to optimally facilitate the absorption of knowledge (Minbaeva et al, 2003).

It would normally be correct to assume that the target unit wants to acquire the knowledge from the sending site. The problems seem to exist when the knowledge is lost in translation or mixed signals. Therefore language plays a central role. Holden (2002) focuses on the linguistic side of international knowledge transfer and defines three major obstacles by means of translation theory: (1) ambiguity – intended knowledge may be misinterpreted by a receiver due to constraints of language or sender: (2) interference - this confusing situation happens when words in different languages look or sound the same, but mean something else: (3) lack of equivalence – when the context of one language is imperfectly transferable to another. Thus the key to international knowledge transfer is the search for a linguistic equivalence for a given body of knowledge in terms of its purpose, content and importance. This view is shared by Cohen & Levinthal (1990) who state that a shared language is essential to productive knowledge transfer, without which people will not understand or trust one another.

Lack of skills or education can also create obstacles in the ability of the receiver to absorb technical know-how. Overby (2004) recognised that during a technical transfer, the receiving site's poor programming experience and knowledge of the project resulted in significant delays in the transfer. The impact of training has been recognised on absorptive capacity (Al-Salti & Hackney, 2011) and risk (Gray et al, 2011). Wang et al (2004) in reviewing knowledge transfers to China, state the better the qualifications of employees the greater the extent of knowledge the China subsidiary acquires from its MNC parent. Chen & McQueen (2010) also state that novices can experience some difficulties in the transfer process due to the low absorptive and retentive capacities, a large knowledge gap, and cultural and communication difficulties. The gap and difficulties that exist between provider and a recipient create a situation of distinct disadvantage for the recipient.

Explicit Knowledge Transfer

Explicit knowledge is defined as information that is captured in documents, procedures or instructions. It is highly codified and is transmittable in formal systematic language (Nonaka & Takeuchi, 1995). Explicit knowledge can be transferred via manuals, templates, blueprints and other written methods and will not require high levels of relational embeddedness (Dhanaraj et al, 2004). Jasimuddin & Zhang (2009) argue that the perceived explicitness of knowledge determines how well a knowledge provider can explicate and document their knowledge to be transferred in an explicit manner within a certain organisational environment.

The availability of formal procedures should make the transfer of technical information and instructions easier. However these can often be misinterpreted or misunderstood (Doz et al, 2001). Some explicit knowledge can be transferred quite easily, although often companies mistakenly believe knowledge is explicit and then discover it cannot be easily explained (Inkpen, 2008). Slepnirov & Waehrens (2008) commented that during the transition from a single to a multi-site set up the documentation of products, processes and technology was not sufficiently developed to make a clean shift. The documentation had been adequate for internal single site relationships and within the scope of the existing problem solving culture that characterised that company. Kohlbacher & Krähe (2007) describe how drawings were re-codified by sending relevant engineering documentation to the overseas company. These were re-drawn with a different cultural and lingual context. The drawings were then checked for correctness and the necessary corrections marked. This technique had the added benefit of bringing the two groups of engineers and engineering managers together. A case study by Jonsson & Kalling (2007) identifies that explicit knowledge was considered as important in both firms studied, who both invested in making it available via manuals and documents in order to share best practices.

Training is a key element for transferring explicit knowledge, especially to a different global location and culture. Chen & McQueen (2010) disclose that engrained and encoded product knowledge was transferred through face-to-face classroom training sessions lasting up to 12 weeks, by US trainers to Chinese operators. For simple, explicit knowledge peer to peer training along with work manuals fulfil the basic requirements of knowledge transfer (Cheng et al, 2010). Inkpen (2008) noted that it took a company a few years before they realised the most valuable knowledge could not be transferred without some face-to-face interaction involving training. Explicit knowledge therefore is an important factor in the transfer of know-how and cannot be overlooked.

Tacit Knowledge Transfer

Tacit knowledge is difficult to express in formal language, comes from experience, perceptions and individual values and depends on the context in which it is generated (Joia & Lemos, 2010). It is not coded and is acquired through the informal take up of learned behaviour (Grant & Gregory, 1997). This hidden aspect of transfers is poorly addressed by the literature (Madsen et al., 2008).

Therefore the know-how held within the host needs to be transferred effectively to the receiving unit. Grant & Gregory (1997) produced a tacitness typology for knowledge bound entities and they state bundles of know-how (knowledge about a process) and know-why (knowledge about relationships within a process) are best transferred by contact with knowledgeable staff, on the job training and visits to the home site by technical personnel. They also write that as tacit knowledge cannot be made wholly explicit the method of teaching becomes critical. The power of training is evident in the Japanese philosophy of knowledge transfer. Pil & McDuffie (1999) shared an example of Mitsubishi purchasing a new assembly line for its transplant facility in the Netherlands in which it sent hundreds of workers to Japan to test the new equipment and improve it before it was even delivered to the plant.

One-to-one or face-to-face interaction is a good method of transferring tacit knowledge (Štrach & Everett, 2006; Riege & Zulpo, 2007; Nelson & Winter, 1982). This transfer is made easier if there is a good relationship between the two transferring principals. Dhanaraj et al (2004) have developed a model that suggests trust is important for the transfer of tacit knowledge (but less so for explicit knowledge). Dyer & Nobeoka (2000) describe how the Toyota Production System creates highly interconnected strong ties

between Toyota suppliers. These ties produce the trust (social capital) necessary to facilitate the transfer of tacit knowledge.

Embodied tacit knowledge is a practical, individual type of knowledge building on practical experience (Lam, 2000). Embedded knowledge resides in organisational routines and shared norms based on shared beliefs and understanding within an organisation. It is the most difficult to transfer because it is not owned by any specific individuals, exists in complex social interactions and team relationships (Chen & McQueen, 2010) and is not systematically managed (Claus, 2000). This reinforces the earlier views that direct contact and hands-on experience is the best way to capture tacit knowledge (Nonaka, 1994; Kohlbacher & Krähe, 2007).

Verification

Verification is required to ensure that knowledge has been correctly transferred. It consists of various tests or audits to stimulate the use of the acquired knowledge by the receiver. The little literature on this topic recognise it as an important tool.

What-if scenarios and scenarios based on real non-standard operation are useful for transferring complicated knowledge (Cheng et al, 2010). Training methods such as presentations, role plays, real call listening, case studies, lab experiments, written tests and quizzes can be used (Chen & McQueen, 2010) as well as simulations and playback as surrogates for experiments to extract the complex and tacit dimensions of knowledge (Chua & Pan, 2008).

Audits are important to check progress against original goals and plans (Overby, 2004). The checks and balances put in place (like a test on capabilities) are the key to preventing a premature sign-off, however, the continuous demands on engineers and engineering managers to tacitly understand and receive knowledge by inspections and audits can be an obstacle in timely execution of a transfer (Kohlbacher & Krähe, 2007).

In summary, the literature research revealed five key themes for the transfer of technical know-how. The five criteria are the willingness of the host site to share the information; the willingness of the accepting site to receive the information; the transfer of explicit knowledge; the transfer of tacit knowledge; and the verification that the know-how has been transferred correctly.

Results

Interview

The interview process sought to enhance the findings from the literature with experience from facility transfer professionals. Five people with domestic and international facility transfer experience in aerospace, automotive, scientific instrumentation and transfer consultancy were interviewed as a result of convenience sampling. The number of people interviewed was relatively low because it soon became apparent that many applied the same tools and techniques and saturation was achieved quickly. The interviews were face-to-face and semi-structured. The prepared structure of the interview was used to ensure all aspects desired were covered. Each interviewee was permitted to deviate to enable exploration of the subject area but was prompted periodically according to the prepared questions. The interviews explored techniques, procedures and styles for the transferring of know-how.

All interviewees followed a procedure and considered the transfer of both tacit and explicit knowledge as a prerequisite for successful transfer. The views differed slightly; those with automotive experience had a simple technique as a result of very detailed standards in place for every manufacturing operation. The transfer of know-how was basically to replicate the production line, apply the exact same standard and train the receiving site on the standard and why it is necessary. In the aerospace and scientific equipment examples, these standards were not as detailed, consequently the technique used was to transfer the blueprints or technical drawings first. This was followed by sending specialists from the donor site to the receiving factory to train new operators. In some instances they would purchase new equipment at the receiving site in order to improve the manufacture of the transferred part, however, this could add delays to the transfer project if problems were encountered. Interestingly, the consultant adopted the most thorough approach, which involved an initial break down of each individual process. Then an understanding of what is known about these processes and what and why something is done at each operation was developed. They would then try and understand the range of possible events for every process. A training programme was developed to train the recipients, both supervisors and shop floor workers.

The barriers encountered when transferring know-how were fear of job/role loss. One interviewee stated that they had even witnessed sabotage by personnel from the transferring site, deliberately passing on false information. Another barrier was the false assumption that people from the transferring site would spend significant time at the receiving site training personnel. Furthermore, the receptiveness of people at the receiving site can be poor, due to their lack of training or ability. They also experienced times when the working conditions at the receiving site were so poor that people from the transferring site refused to stay. Other barriers noted were blueprints or drawings being out of date so the latest standard was not copied.

There was variation in the types of verification or validation used. In some examples, the product was manufactured and assessed to ensure it met the correct standard or the same quality standard as the donor site. Once the correct standard was made, a large batch would then be made to understand the process capability. Again, in some examples this was compared to the donor site's capability and in others they had to reach a target. The highly technical and expensive examples had a first-off inspection regime, whereby every feature was inspected to ensure compliance with the drawing. Finally, others mentioned that audits at every operation would take place.

There was a difference of opinion on how cultural differences were overcome. Some felt that there were no differences; if you transferred the knowledge correctly by having good, uncomplicated standards and training it did not matter where the process was transferred. Others felt that it was easier to transfer knowledge to the Far East as the populations are hungry to learn, while those in the USA and Europe are reluctant to give knowledge. Almost all interviewed offered caution about the potential misinterpretation of language in complicated instructions.

When asked about the successes of the facility transfers, all claimed they had been successful. The only two common themes of failure were going over budget and over the allotted project time scale. There was a unanimous view that the transfer of technical know-how was a shared responsibility, "It's a hand shake", a partnership that both sites are accountable to deliver.

In summary, the transfer of know-how requires that all the processes to be transferred must be broken down and detailed standards created. Extensive training of the process and standards from the donor site to the receiving site is fundamental. Verification and validation must include a detailed inspection of the

first component and an audit of each of the processes. Lastly, the transfer is a joint venture where both sites have a shared responsibility. The interviews enabled the findings of the literature review to be confirmed accounting for any publication lag and to enhanced the base on which to develop the questionnaire.

Survey

A survey was generated based on the key findings from the literature research and interviews regarding the transfer of technical know-how. The purpose of the survey was to further explore the key factors and barriers associated with these five key themes.

It was specifically designed to understand the motivation to share their knowledge and mechanisms to transfer know-how. In order to be able cross tabulate replies against different demographic populations and job roles basic data was collected on time in company, role in company and age. These opening questions also eased the respondent into the questions. The five themes emerging from the literature were used indirectly in the questions to avoid act adverse reaction to abstract questions by the respondents. The questionnaire focused prominently on successful factors and barriers focus for both domestic and overseas transfers for these themes. Hence the themes cut across the questions rather than were the focus of the questions. Finally, the questionnaire invited comments from respondents to enrich the results. The questionnaire was piloted for usability. Changes to presentation and meaning were made prior to release to the target population.

The survey was sent to 173 people predominantly within the technical community of a large company by e-mail invite to web-based survey tool. A total of 110 people replied to the survey giving a participation rate of 64%. It is noted that this is a high response rate compared to an average 33% response rate to e-mail based surveys (Hoonakker & Carayon, 2009) and 52% to mail based. Typical of a web-based, survey most responses were received within the first three days of launch. The highest response was from those describing themselves as engineers (50%), managers (28%) and laboratory (14%) with a small representation from quality and contractors.

Against the factors for sharing know-how with another party it was found that reward or incentive for sharing scored much lower than other possible answers (Table 1). This does not reflect the literature where reward or incentive is seen as important for sharing knowledge. However trust and good leadership both scored very highly, confirming what was often cited as a key component to sharing know-how in the literature. Over 25 other comments were collected for this question, the majority of which included good communication being a crucial part of sharing know-how.

Factor	Importance	Least 1	2	3	4	Most 5	n/a	Average importance
Reward/incentive for sharing		23%	25%	12%	12%	6%	3%	2.52
Relationship/trust with other party		2%	3%	8%	35%	53%	0%	4.34
Good leadership		2%	6%	11%	35%	46%	0%	4.17
Duty as employee		5%	12%	27%	31%	22%	3%	3.54
Other (comment)		0%	4%	9%	4%	32%	51%	4.30

Table 1. Importance of factors for sharing technical know-how with another party

The responses to the first question were endorsed by the next question on the barriers to sharing know-how. Lack of reward or incentive had the lowest rating once again (Table 2). The other three key barriers of

poor communication, lack of time to transfer knowledge and fear of job loss all scored highly. The other comments captured varied and included language barriers and fear of passing on knowledge to the competition.

Factor	Barrier	Least 1	2	3	4	Most 5	n/a	Average barrier
Lack of incentive		23%	20%	33%	12%	10%	2%	2.63
Fear of job loss		10%	14%	14%	24%	35%	3%	3.61
Poor communication of reasons for sharing		3%	9%	23%	38%	27%	0%	3.78
Too much info to transfer in allowed time		7%	10%	22%	36%	25%	1%	3.62
Other (comment)		0%	2%	10%	14%	29%	45%	4.26

Table 2. Key barriers to sharing technical know-how with another facility

Those who had less than five years service put fear of job loss as the smallest barrier. When compared to the rest of the sample, for those with longer service it was the largest barrier. When analysed by job function, managers overwhelmingly had fear of job loss as the largest barrier (noting that managers typically had more than five years of service).

Examining the key factors for successful transfer of know-how to an overseas facility, all respondents considered programme management, upfront training of personnel, good communication and a fully documented method of manufacture as very important (Table 3). Additional comments to note were strong / good leadership and qualification of the manufacturing procedures that are in place.

Factor	Significance	Least 1	2	3	4	Most 5	n/a	Average significance
Good programme management		3%	4%	13%	26%	53%	1%	4.25
Train upfront receiving facility personnel		1%	6%	12%	36%	44%	2%	4.17
Good communication about the transfer		1%	8%	12%	31%	47%	2%	4.17
Fully documented method of manufacture		4%	2%	8%	16%	70%	1%	4.47
Other (comment)		9%	3%	0%	3%	43%	43%	4.20

Table 3. Most significant success factors for overseas transfer of technical know-how

The two main barriers to overseas transfer of know-how obtained from the survey were lack of willingness to share information and perceived lack of skills / knowledge of the receiving site's personnel (Table 4). Additional comments had two strong themes: potential cultural differences of the sites and the potential distance of the sites hampering ready support. When assessing the different lengths of service, people who had less than 11 years service considered language differences to be the smallest barrier, while those with more than 11 years service considered language differences to be the largest barrier.

Factor	Barrier	Least 1	2	3	4	Most 5	n/a	Average barrier
Language difficulties		5%	24%	26%	28%	18%	0%	3.31
Technical ability/skills of receiving personnel		2%	9%	24%	36%	28%	1%	3.79
Highly technical products cannot be copied		14%	30%	17%	17%	18%	5%	2.92
Lack of donor facility willingness to share		2%	10%	22%	38%	28%	0%	3.79
Other (comment)		5%	3%	3%	21%	31%	39%	4.13

Table 4. Most significant barriers to overseas transfer of technical know-how

A difference of opinion associated with the length of service was also evident on whether complex products could be transferred. People with less than 11 years service said that the new facility would be successful because it would have a better working culture. However, the over 11 years of service category said the facility would not be successful because the new personnel would not have enough product knowledge (Figure 1). The responses to this question were interesting, as there is a clear split of opinion. The majority, 46%, felt that the new facility would not be as productive after the first year of operation because of poor product knowledge. While over 27% felt it would be as productive after the first year because of a better manufacturing culture. This implies 46% of the respondents felt that the tacit knowledge of a complex component could not be fully transferred within the first year of operation.

Some respondents felt if the product was complex, but the processes were capable, then it could be transferred easily and successfully. However if the processes were not capable, then the receiving site would struggle and would require support from the parent site.

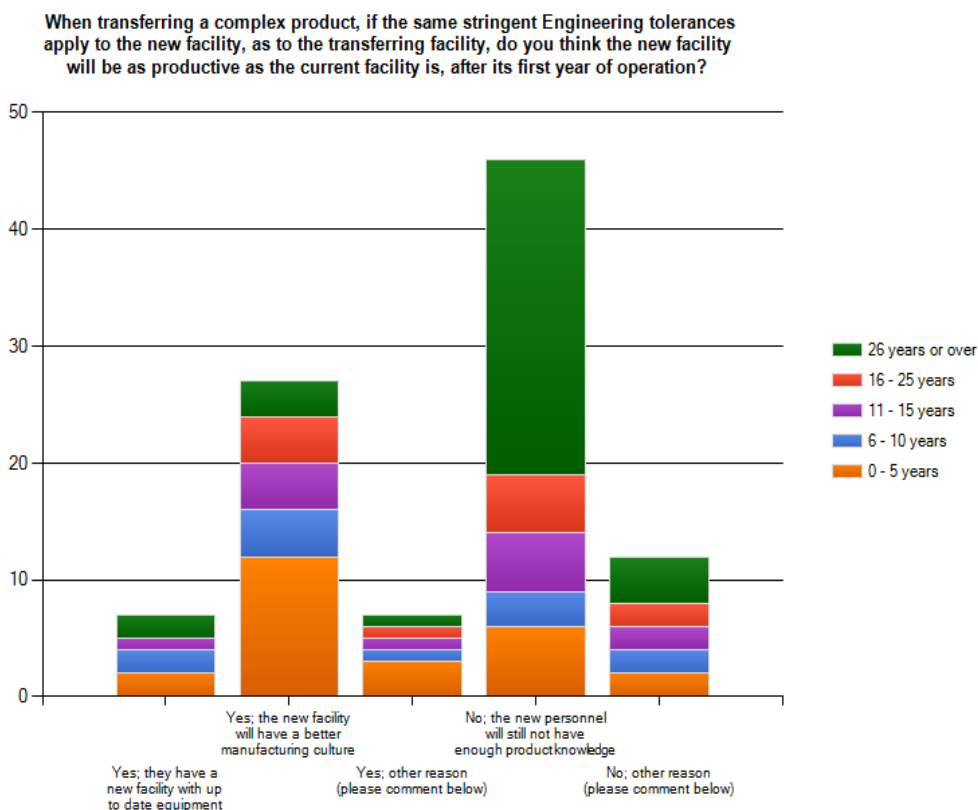


Figure 1. Perceptions on productivity of new facility one year after transfer

Finally, 40 comments were made regarding the transfer of know-how covering three themes. First, good detailed planning with appropriate risk management helps highlight the highly tacit operations. Second, good listeners and communicators are needed to work with individuals to document all activities regarding processes and capture the ‘know-why’ as well as the know-how. Third, communication and understanding from the outset. This would, in their opinion, make people more receptive to sharing their know-how with other parties.

To summarise the survey findings, incentive was not seen as a major factor in sharing know-how. Trust, relationships and good leadership were considered to be key factors to sharing. Communication is crucial but could also be a barrier if done poorly. Other barriers for sharing know-how were fear of job loss and

lack of time. Furthermore, a comprehensive detailed method of manufacture and advanced training of the receiving site’s personnel were stressed as very important to tacit knowledge transfer. A supplementary worthy observation was that people who had been at the surveyed company for over 11 years had, in general, different views to those of less than 11 years service.

A Framework for the Transfer of Technical Intellect

The observations, judgements and analysis from literature, survey and interview were assimilated to create a framework for the successful transfer of intellect from one facility to another. The research highlighted five key subjects that are paramount to the successful transfer of know-how of: willingness to share information; willingness to receive information; explicit knowledge transfer; tacit knowledge transfer and verification. These are the basis for the framework shown in Figure 2. The framework shows the flow of information and knowledge from the transmitting site to the receiving site from left to right. The research established that leadership, communication and relationship management were foundations for any transfer and these are shown as necessary to establish in the first phase before proceeding. The five themes drawn from the literature are shown central to the diagram. Three of the themes are represented as process phases of explicit data qualification, tacit data capture and verification. The themes on the willingness to share by the transmitting site and the willingness to receive by the receiving site are not process phases as such but are key areas of attention that will enable or hinder the process of transfer of technical intellect.

Transmitting site	Willingness to share	<i>Phase 4</i> Verification Capability ▪ Autonomy ▪ Testing	Willingness to receive Motivation Expectation Ability Education	Receiving site
	Motivation Trust Perception Fear Timescales Reward	<i>Phase 3</i> Tacit data capture Training ▪ Face-to-face ▪ Know-why		
		<i>Phase 2</i> Explicit data qualification People ▪ Review ▪ Accuracy ▪ Understanding		
	<i>Phase 1</i> Foundation Leadership ▪ Communication ▪ Relationship			

Figure 2 Transfer of Technical Intellect Framework

Foundation of the Transfer of Technical Intellect Framework

The foundation is the first phase of the framework. It begins with *good communication* about the facility transfer encompassing all available information regarding the transfer that can be divulged to all affected personnel. This was stressed in the survey as a major factor in the successful transfer of know-how to alleviate concerns about any facility move and leads to an increased willingness to share information with other parties. Conversely, if it is done incorrectly it can have a larger negative impact and will cause people to be very reluctant to share knowledge. It could also have a detrimental effect on the donor plant’s efficiency due to a disgruntled, less productive workforce.

Effective briefing of the donor site establishes a *good working relationship* with the receiving site (Dudley, 2006). This is attained by early dialogue and face-to-face meetings. Forming a good relationship between

experienced workers and trainees increases the likelihood that tacit knowledge will be disclosed as the holder of the knowledge is willing to help the trainee and the trainee will also not be inhibited or afraid to ask questions. This observation is even more pertinent when attempting to pass tacit knowledge between different levels of the management structure. Where there is a poor relationship and intimidation, workers selectively withhold information that could be important but might reflect badly on themselves (Riege & Zulpo, 2007).

The final item of the foundation is *good leadership*. People follow and trust good leaders. Through good leadership therefore workers will be open with their superiors and communicate factually without distortion. A good leader will have a vision in relation to the transfer and will motivate their and other teams to believe in that vision. Both the literature and the survey recognised leadership as a key factor in successful knowledge transfer. Particularly, leadership appeared as significant in both literature and survey results concerning the willingness to share information.

Qualification of Explicit data

The second phase of the framework is to start the transfer of knowledge and ultimately know-how between the donor and receiving site through the qualification of relevant explicit data. The intent of this phase is to start the integration of the two transferring sites' personnel and to acquire a thorough and detailed understanding of the operations involved in the manufacture of the components to be transferred. Provision of the fully documented method of manufacture was one of the most emphasised aspects from the survey.

The phase begins with the selection of the *people* facilitating the transfer of this data. The individuals from the donor site must be conversant with the technical documentation and able to communicate and train effectively. They must also be sufficiently motivated to explain the intimate and important details of these instructions. The individuals from the receiving site must be of the correct aptitude to understand the manuscripts and, in the example of an overseas transfer, be able to understand the common language of the transmitting site's personnel. Many survey respondents cited peoples' attitudes and language skills as very important here.

Next is *review*. Qualification of the manufacturing instructions is necessary. The extent of this process depends upon the following critical factors. First is the complexity of the transferring part and the level of detail and precision of the current standards that are in place. For simple transfers Cheng et al (2010) deem work manuals as sufficient but interviewees noted that for complex products with a large amount of controlling documentation the transferring site must first validate all the current documents. The purpose is to ensure that all the instructions are up to date and that tooling or controlling parameters have not been modified without the drawings or instructions being updated. When this has been completed the conveying site will have confidence that the fixtures, tooling and technical controls of the transferred part are accurate and represent the current process and can be replicated at the receiving site.

A further vital requirement is the *understanding* of these controlling documents, in particular in an overseas transfer. If the receiving site's native language is different from the transferring site's, then it is important that the instructions are checked for any potential misinterpretation as noted by Kohlbacher and Krähe (2007). This is best performed by a joint, face-to-face, review of documentation (Inkpen, 2008). Not only can both parties interact and question any ambiguity, but they also start to form a relationship which will aid the transfer of tacit knowledge.

The *accuracy* of the standard has a bearing on the ease of transfer of explicit knowledge. Detail of a task or operation should be broken down into smaller tasks and so on, until all the detail is captured, leaving nothing to chance and allowing deviation from the standard was stressed by several interviewees. Therefore when a process is transferred, the only requirement is to know how and why the standard is applied.

Capture of the Tacit Knowledge

The third phase of the framework is to capture the hidden know-how of the processes to be transferred. It capitalises on the relationships and trust developed in the second phase of the framework to allow the “tricks of the trade” or the tacit knowledge to be extracted from the personnel operating these processes. This phase begins with the training of the receiving site personnel on the operations they will be running after the transfer as noted by Pil and MacDuffie (1999) and underlined by interviewees.

Survey respondents stressed that *training* whenever possible has to take place at the transferring site’s manufacturing facility prior to the transfer commencing. The time period for this training is dependent on the complexity of the process to be transferred. Although it should be noted that if the training is for a short time period only, the relationship may not be mature enough for all the know-how to be revealed or captured. Interestingly it is noted by facility transfer professionals that the length of training is often assumed to be longer than is actually required. The aim of the training is simply for the receiving site’s operator to understand intimately the intricacies of the process to be transferred. During the training they must appreciate not only how a particular task is performed, but why it is performed. This is attained by initially comprehending the standards and documentation for the operation and how it is performed, as covered in phase two of the framework earlier.

The *face-to-face* training that supports the capture of non-documented activities is well covered in the literature. These can vary from how to load and unload a component, what position to start the process, how to clean a die or fixture, etc. These techniques have been developed over many years by the donor site’s experienced personnel and contribute to the improved performance of the operation. Interviewees supported Nonaka (1999) that to further enhance the trainee’s know-how, this hands-on training should be repeated with different experienced personnel so that all the variations and their outcomes are captured. Additionally this will verify the techniques and will overcome any non-disclosure of tacit knowledge by an unwilling trainer.

Finally, to further enhance an individual’s know-how of a process, a series of non-standard events must be devised to tackle the ‘*know-why*’ was emphasised by interviewees. The purpose of these events is to extract further knowledge from the trainer that they had not realised they possessed. By creating a non-standard event, the trainer relies on their know-how to resolve the problem. Since non-standard events are somewhat difficult to predict, then there is no standard sequence to settle the issue. The knowledge that is used to conquer the problem is therefore nearly always tacit. The trainee can observe these events and acquire a greater insight and hence know-how of the operation.

Verification of the Know-How

The fourth part of the framework is the verification of the transferred know-how. This establishes that the knowledge of the transferred process has been correctly conveyed to the receiving site.

The strong theme that emerged from the interviews was that the *process capability* of the transferred process must be equivalent or better than its original value at the donor plant. Final commissioning of the relocated operation would not be passed off without demonstrating achievement of the target process capability. Although this is considered an important part of the verification method within the framework, it does not necessarily mean that sufficient know-how has been transferred. However, if the process capability is sustained over a three month period when the receiving plant has been run autonomously it can be assumed that the know-how has been transferred successfully. Formal audits of the new site by the donor site are another way to verify the successful knowledge transfer. Audits can be designed to test both explicit knowledge, such as is the correct documentation in place, and tacit understanding by probing the knowledge of the individuals about the process. The completion of actions resulting from the audit process also facilitates the attainment of know-how.

Another possible form of verification is to allow, after comprehensive training, the receiving site to run the operation *autonomously* for a defined period at the donor site prior to the transfer. This experience will confirm that the learning and know-how gained through their training period has been successful. It would also allow for any additional know-how to be captured that might have been omitted whilst the operation was being observed.

The final form of verification is *testing* the receiving personnel. Chau & Pan (2006) highlighted that examination of the receiving site personnel was an effective way of comprehending the full extent of the know-how transferred. The tests should be derived to probe both explicit and tacit knowledge. These assessments can also highlight any gaps in the training regime or know-how transferred, by evaluating the responses and identifying any subjects where the majority of examinees answered incorrectly. This form of testing can be extended into non-standard event investigation. Questions would be asked about unusual events or scenarios to understand the receiving site's ability to solve the problems. Additionally these can enhance the learning and acquiring know-how by performing a detailed post examination review of the model answer with all the individuals.

This work captures the knowledge transfer themes of willingness to share information, willingness to receive information, explicit knowledge transfer, tacit knowledge transfer and verification in a single Transfer of Technical Intellect framework. It draws on literature and empirical data capture. The work is distinct from that published by integrating the key themes in a single framework, for example, it places significant emphasis on foundations and verification compared to others (e.g. Chang et al (2010) and Al-Salti & Hackney (2011)) and is supported by data from across sectors.

Conclusion

The globalisation of manufacturing operations has resulted in the requirement for the successful transfer of technical intellect as companies expand or relocate. The demand to discover the most efficient and effective methods to transfer knowledge has resulted in an abundance of research into the theory of knowledge transfer. This paper further explores this subject, analysing peer reviewed literature and over 100 responses from a large technical community through an email questionnaire as well as interview. It uniquely identifies five key themes for the successful transfer of know-how. The themes are willingness to share information, willingness to receive information, explicit knowledge transfer, tacit knowledge transfer and verification.

The key themes are used to derive a Transfer of Technical Intellect framework. The framework depicts the essential criteria and stages required for the successful transfer of technical know-how to a new facility. The four key stages propose the ideal conditions for accomplishing the transfer of technical intellect. Firstly, the foundation is good communication, strong leadership and relationship building. Selecting the correct people to lead the transfer is critical. The next phase is the qualification of explicit data, through the detailed review of controlling documents and the creation of an exhaustive and thorough standard for all the operations to be transferred. This phase is followed by the capture of all the tacit knowledge ('know-why') by intensive on the job training. Finally, the verification stage which ensures, through audits, examination and process capability, that the know-how and know-why of all the processes has been transferred successfully. Overarching the whole structure is the workforce interaction of both the transmitting and receiving sites' personnel. Without this vital component of the framework, the transfer of intellect and knowledge would not be fulfilled. These different but equally important phases make up the proposed framework for the transfer of technical intellect.

The Transfer of Technical Intellect Framework draws previously separate research work together and tests it by interview with experienced practitioners and a survey engineers engaged in or affected by parts transfer. The framework has the potential for use to guide others in parts transfer activities, however, the work needs to be tested for generalisability outside the aerospace sector.

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