

KNOWLEDGE- SHARING WITHIN THE PROJECT-BASED ORGANIZATION: A KNOWLEDGE-PULL FRAMEWORK

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ABSTRACT

This paper examines mechanisms to use lessons learned on individual projects within an organisation. A Delphi study highlighted the organisation's responsibility for incorporating knowledge from projects into a project management methodology. Knowledge from a project should be transferred through a centralised knowledge management function that should evaluate codified knowledge within the context in which it was generated, determine how the knowledge should be used, and maintain the explicit knowledge database and the knowledge flow process. Based on a literature review, structured interviews, archived data, and a Delphi survey, a framework for transferring knowledge to the organisation is proposed. The framework enables the organisation to motivate and guide knowledge transfer within a methodology that indicates where, when, and how knowledge transfer and use should take place.

OPSOMMING

Meganismes om lesse wat op projekte geleer is in 'n organisasie te gebruik, is ondersoek. 'n Delphi studie het die verantwoordelikheid van die organisasie t.o.v. die inkorporering van kennis in 'n projekbestuur-metodologie uitgelig. Kennis vanuit 'n projek behoort via 'n sentrale kennisbestuur-funksie oorgedra te word. Hierdie funksie moet gekodifiseerde kennis evalueer in die konteks waarin dit ontwikkel is, bepaal hoe die kennis gebruik behoort te word, en die databasis asook die kennis vloeiproces instand hou. Op grond van die literatuur, gestruktureerde onderhoude, geargiveerde data en 'n Delphi opname, word 'n raamwerk vir die oordrag van kennis na die organisasie voorgestel. Die raamwerk stel die organisasie in staat om die oordrag van kennis te motiveer en te lei in 'n metodologie wat aandui waar, wanneer en hoe kennisoordrag en benutting behoort plaas te vind.

1 INTRODUCTION

Project-based organisations (PBOs) are defined as organisations that mainly use projects to produce products and/or services [1]. The organisational capabilities, knowledge, and resources are developed and improved through the process of executing projects and sharing the lessons that were learned and developed through the project's execution. Once shared, these lessons learned can be used by subsequent projects to improve organisational capabilities [2, 3]. Knowledge-sharing was defined by Yang *et al.* [4] as the degree of communication and distribution of experience, expertise, and ideas amongst employees of an organisation. A lifecycle-based project management methodology is typically adapted within the PBO, dividing the project lifecycle into stages, each with a set of specific deliverables. These typical project stages, which are outlined in Figure 1, broadly consist of initiating, developing (which includes front-end engineering), implementing (which includes basic and detail engineering, documentation, procurement, and construction), operating (including commissioning), and closing the project [5, 6]. A closeout meeting at the end of a project can be used to capture knowledge gained during the project and to transfer that

knowledge to other projects and to the rest of the organisation. On large projects, however, such meetings are not very effective because much of the knowledge has generally been lost by the time of project closure. Additional closeout meetings at the end of each project phase are therefore valuable, as well as after-action reviews immediately after an important event to debrief and learn from the event [7].

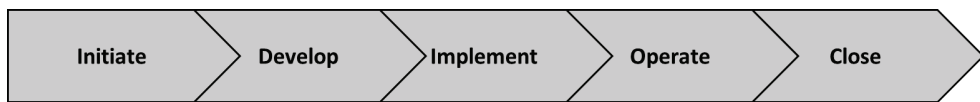


Figure 1: Typical project stages [5, 6]

Knowledge Management (KM) is seen as the process of systematically acquiring, converting, disseminating, using, and protecting knowledge in a structured manner, following the specific organisational knowledge strategy [4, 8, 9]. Moreover, the literature outlines several KM processes within the knowledge lifecycle, which include identifying, capturing, acquiring, collaborating, creating, assembling, storing, integrating, experimenting, retrieving, sharing, transferring, and using it [10-12]. Challenges with the management of knowledge are well-documented, and relate to all aspects of the knowledge lifecycle [1, 3, 13]. The organisational structure can inhibit knowledge transfer and effective KM. A functional organisational structure, for example, acts as a knowledge silo where knowledge is created but not necessarily transferred or disseminated throughout the rest of the organisation. The unique and inherently transient nature of the projects themselves also poses several problems. These include misalignment between the short-term objective of the project and the long-term objectives of the organisation, and the risk that a project resource will leave the organisation with new knowledge still embedded and not yet transferred [1, 2, 13].

In general, the main barrier to knowledge transfer in projects can be seen as a lack of motivation from the project team. However, studies have found that the main barriers to knowledge transfer relate to the absorptive capacity of the parent organisation and the ambiguity of the knowledge itself [14, 15]. A study by Szulanski [15] concluded that the main barrier to knowledge transfer is the knowledge 'pull' from the organisation rather than the knowledge 'push' required and initiated by the project. From a project perspective, there is some ambiguity about where the primary responsibility for KM lies. If the project manager is responsible, knowledge should be 'pushed' into the organisation. However, studies have shown that the responsibility should rest with the organisation, which can result in a requirement to pull knowledge into the organisation [15-17]. The framework presented in this study aims to address these concerns, focusing more on the responsibility of the organisation.

Boh [3] outlines a framework that depicts the mechanisms for intra-organisational knowledge transfer based on the size, geographical dispersion, and nature of the organisational tasks. The mechanisms outlined consider both personalisation and codification as valid transfer mechanisms, as discussed by Hansen *et al.* [17]. It also considers another dimension of knowledge sharing: individualisation versus institutionalisation. Both tacit and codified knowledge transfer are supported as part of the organisation's KM strategy [13].

In order to improve project success, the objective of this study is to develop a knowledge-pull framework that will enable the organisation to identify, codify, and transfer knowledge gained from the project's lifecycle stages that the parent organisation deems important for supporting the organisational KM strategy. For the purposes of this research, the following research questions are formulated:

1. What types of knowledge currently exist in PBOs and need to be captured by the PBOs from the different project stages?
2. What transfer mechanisms should be used, and what transfer process should be followed by PBOs to capture knowledge from projects?
3. How should PBOs disseminate knowledge within their organisations, and what are the enabling factors?

These research questions led to the development of a framework that aims to explore the process of knowledge-pull by the organisation from its projects, and the knowledge dissemination process

within the organisation that enables relevant and valuable knowledge to be transferred from the organisation to other projects.

2 TOWARDS A KNOWLEDGE-PULL FRAMEWORK

Szulanski [15] found that the absorptive capacity of the organisation is key for ensuring knowledge transfer. Exploration and exploitation of knowledge are important parts of absorptive capacity. During exploration, the organisation should pull the knowledge from the project. This can only be achieved if the organisation can identify the value of the knowledge, where it will be transferred to, and how it will be disseminated. This will enhance knowledge exploitation. Once the project resources understand these requirements, it will also motivate and support knowledge transfer by the project resources.

Zollo and Winter [18] outline three learning processes associated with learning within the PBO environment: experience accumulation, knowledge articulation, and knowledge codification. These learning processes are used within the project to obtain or learn new knowledge. The knowledge is then packaged and transferred to the organisation where it can be disseminated and used within other projects and the organisation in general [16]. Learning takes place through organisational routines, knowledge articulation, and knowledge codification. Organisational routines are a behavioural learning process, learning through experience, used to improve the current organisational procedures [16, 18]. Knowledge articulation and codification are more evolved learning processes, as understanding the causation between the action and resulting performance is required. In addition, the codification process requires an understanding of the process within its context, together with a consideration of future actions [1, 18, 19]. KM processes are used to transfer the lessons learned from the project into knowledge that can be shared and disseminated. Dissemination is therefore a crucial factor within KM in general, and specifically the knowledge-pull framework [10].

The knowledge transfer mechanisms used within the proposed knowledge-pull framework are based on the framework proposed by Boh [3]. Depending on the size and geographical dispersion, the organisation will make use of some or all of the mechanisms. As shown in Table 1, these mechanisms are (1) individualised-personalisation, (2) individualised-codification, (3) institutionalised-personalisation, and (4) institutionalised-codification. The introduction of the centralised function will also bridge the gap between the permanent and temporary structures and resources [20]. All mechanisms were used within the scenarios depicted by the respondents.

Table 1: Knowledge transfer mechanisms (adapted from Boh [3])

	Individualised	Institutionalised
Personalised (Mainly tacit knowledge)	Knowledge-sharing occurs as part of person-to-person interactions between individuals and is informal in nature: e.g., social networks.	Knowledge-sharing occurs in a personalised way, but is institutionalised within the routines and structures of the organisation: e.g., mentoring programmes.
Codified (Mainly explicit knowledge)	Knowledge-sharing occurs for an individual, and is documented in an informal and ad-hoc manner: e.g., informal documentation.	Knowledge-sharing is institutionalised within the routines and structures of the organisation and is documented in a formal knowledge management system: e.g., document repository.

Knowledge within the PBO can be considered within the context of the knowledge stock, enabling environment, and knowledge practices [21-23]. It is the responsibility of the organisation to create the KM-enabling environment and to implement and maintain the knowledge practices. KM practices have evolved from the initial simplified idea of only focusing on a central repository to support easy access by relevant resources. However, as outlined above, this practice is still crucial to KM success. Efficient use of the repository requires a shared language and terminology to ensure that the material is correctly archived for future retrieval and use. This requires the introduction and understanding of semantic resources, knowledge taxonomies, and a coordinated classification system [24]. In addition to this, the organisation should put systems in place to build the knowledge

stock within the organisation. It is then the responsibility of the project manager and project team to focus on KM, and to adhere to and make use of the knowledge practices within the enabling environment [1, 9, 25]. The way in which the knowledge is converted, disseminated, and applied within the organisation will ultimately enable success. When studying the transfer of knowledge between the project and the organisation, the important factors to consider are the characteristics of the knowledge source, the recipient, the knowledge itself, the characteristics of the context within which the knowledge transfer took place, and the absorptive power of the recipient [10, 14, 26-28].

Reich *et al.* [21] propose that KM within the organisation should be investigated with regard to the knowledge about the organisation (procedural or know-how), knowledge about the business value (the market), and knowledge about the technology (know-what). This leads to value assurance of the knowledge for the organisation, and should be conducted by a centralised function within the PBO [21].

The resources within the organisation that assist with value assurance can assist the project team to master the technology, project content, and effective project management practices with short delivery times and rigorous quality checks [29]. In PBOs, the value assurance function can be the responsibility of the project management office. That office should then guarantee the quality of the delivery of the project and play a role in the flow of knowledge into the organisation. The initial value assurance or quality control step executed by the project management office or other centralised function will ensure that the knowledge transferred by the project improves the current knowledge base. This function is also aptly positioned to ensure that knowledge is disseminated to the other relevant projects [29, 30].

Based on the discussion above, Figure 2 outlines the initial-proposed framework of flow of knowledge into the organisation.

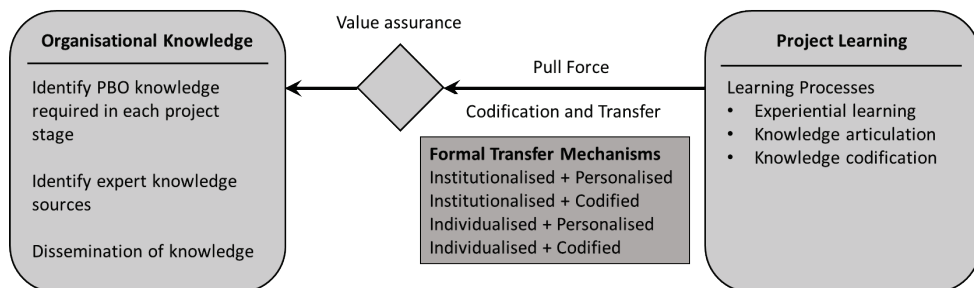


Figure 2: Initially-proposed knowledge-pull framework

The knowledge-pull framework is a result of the interaction between the project learning and organisational knowledge dimensions. The first consideration is the learning that takes place within the project itself. Depending on organisational factors (receiver characteristics), factors within the project (sender characteristics), and the degree of articulation and aggregation, different knowledge transfer mechanisms are used to transfer the knowledge to the organisation. The framework outlines the processes required by the organisation to ensure that the knowledge can be transferred as part of the project execution workflow and disseminated throughout the organisation.

The organisation requires specific knowledge per project stage and needs to have the absorptive capacity to receive the knowledge from the project. The project manager should ensure that the knowledge is packaged in such a way that it supports effective knowledge flow from the project to the organisation. This should ultimately support use of the knowledge by other projects in the organisation.

3 RESEARCH APPROACH

In order to refine the proposed framework, an exploratory research approach is adopted. As proposed by Mouton [31] and Welman *et al.* [32], a mixed-method research approach was used to outline a proposed conceptual framework prior to data gathering. The researchers approached the research project by first studying the general KM literature. The literature review and discussions

with experts were used to develop the initially-proposed knowledge-pull framework. A Delphi study methodology was then adopted to improve and refine the proposed knowledge-pull framework [33, 34]. Using the work of Babbie [35] and Saunders *et al.* [36] on research methods as guide, data about the proposed knowledge-pull framework was sourced through semi-structured interviews, archive records, and a Delphi study with experts in the field of knowledge management in PBOs.

For this study, several experts were identified from three companies in the South African petro-chemical industry, referred to in this study as Companies A, B, and C. Company A is an international chemicals and energy organisation that has 30,000 employees operating in different countries. This organisation is structured into operating business units that are responsible for the production of the organisation's various products; strategic business units; and group functions. The experts consulted for this study were selected from within the group function of the organisation that is focused on delivering small- to mega projects within the organisation. Company B is an engineering design house with 9,000 employees working in several countries. The organisation has expertise in the mining, energy, and infrastructure sectors, and executes small to mega projects. Company C is a consulting firm proficient in business development, project development, project execution, and operations. This organisation primarily supports large industrial capital projects in the oil, gas, and energy manufacturing sectors. Experts from the respective organisations were chosen to ensure that the study included the expertise from the different perspectives of an owner's organisation, an engineering, procurement and construction management (EPC) organisation, and consultants. The organisations all execute small to mega-sized projects.

A total of eight experts were identified to be interviewed as part of the Delphi study. All the interviewees had a minimum of 10 years' experience in projects. Three of the interviewees had between 20 and 30 years' project experience, while another three had more than 30 years' project experience. A number of interviewees also indicated that they were involved in international projects. Their respective backgrounds included experience in the business track of the organisation, sponsorship of projects and commissioning management, engineering management, as technical directors and in functional management, project management and programme management, and in supporting roles within projects, facilitation of lessons learned, framing and alignment, project kick-off and determining roles and responsibilities in order to optimise and maximise the benefit to the project as well as organisation.

Initial semi-structured interviews were conducted with two employees from company C. The objective of these interviews was to form a preliminary view and understanding of the knowledge-pull framework that was defined from the literature. The Delphi study questionnaire was based on the literature review with specific focus on studies completed by Boh [3]. After the initial round of semi-structured interviews, the interview questions for the Delphi study were modified to incorporate the initial findings and better suit the knowledge-pull framework's definition.

In line with the exploratory research design, a purposive sample was required to identify the experts needed to answer the research questions, rather than a sample representation of the general population. In this case, the researchers' personal network was used to identify suitable candidates for the Delphi study in the three organisations. In two instances, a respondent within the organisations referred the researchers to other suitable respondents for the Delphi study.

The first round of the Delphi questionnaire was sent out to the selected sample of eight experts by means of a personalised e-mail one week prior to the interview. Respondents were encouraged to read through the questions in preparation for the interview. The moderator then personally conducted an interview with each of the eight respondents. Each interview was recorded and transcribed; from these transcripts, an informal content analysis was performed.

Results from the first round were analysed according to the research paradigm. The number of rounds were dictated by the consensus reached from each previous round and by the required end result, as proposed by Skulmoski *et al.* [34]. After the completion of the first round of the Delphi study, the experts had not reached consensus. The knowledge-pull framework could be updated, however, based on the responses of the experts. The summary of the different responses for each question and the updated and refined knowledge-pull framework were sent through a second round. Half the respondents participated in the second round and the final responses indicated consensus on the updated knowledge-pull framework; as a result, no further rounds were performed.

The Delphi questionnaire began with three questions on the respondent's background, role in the organisation, and experience level. A fourth question investigated the project lifecycle used in each respective organisation. The project lifecycle stages outlined by the respondents were well-aligned with the literature, and could easily be related to the five stages mentioned earlier in this paper. The lifecycle stages were used to analyse questions around the specific knowledge required for each lifecycle stage.

The results of each question in the Delphi questionnaire were analysed by identifying key words and phrases and summarising the responses. As proposed by Page and Meyer [37], informal content analysis consists of first scanning the content for recurring and repeating words, concepts, or themes, then constructing the summarised feedback of the results. This technique was used in order to arrive at a consolidated response as it allows for the wide spectrum of results. To verify the summarised or consolidated feedback, the results were returned to the initial respondents for review, confirmation, and/or comment. The proposed knowledge-pull framework was then updated for final review. A summary of the results are outlined in the next section.

4 RESULTS FROM DELPHI ROUND ONE

4.1 Knowledge transferred and the organisation database

The aim of the first section of the Delphi questionnaire was to determine the state of the existing knowledge databases in the organisations and the knowledge available and transferred to the respective organisations.

4.1.1 *Explicit knowledge*

The respondents echoed the salient concerns about explicit knowledge found within the literature [3, 9, 10, 13, 38]. They supported the need for a disciplined KM culture in the organisation, which is also promoted by other authors [10, 19, 39].

The notable central concern of the respondents was the loss of context as the knowledge is codified; this finding is also described in the literature [8, 15, 28].

“Within the knowledge centre are links to specifications, standards, business and technical templates, and research sites... good systems with functional search functions [are] in place... The database is also supported by a call centre manned by competent personnel to give technical support with regards to various aspects of a project.” (Respondent 1)

“Technical know-how is done well... Specs are updated on a regular basis... specifications state that for specific vessels, [one should] use standards and then state options and implications. You need to also state where the knowledge came from.” (Respondent 7)

“It is of no purpose to have knowledge of policies and procedures, but the context to apply [it] is not created.” (Respondent 3)

“Throughout all my lessons learned and facilitating different sessions, the biggest lesson I learned was that you have to describe the context very well.” (Respondent 6)

“The full context of the lessons learned is also important... The [project management methodology of Company A] with templates, practices, and work flows is a summary of the organisational knowledge.” (Respondent 8)

“Tacit knowledge is the knowledge that guides you in handling the explicit knowledge.” (Respondent 5)

4.1.2 *Receiving explicit knowledge*

The respondents highlighted two aspects to take into consideration when transferring knowledge to a recipient: absorptive capacity and the timing of the actual transfer. These two aspects are also mentioned in the literature [9, 14, 15]. The respondents noted that the absorptive capacity can be increased through initial training and continued accumulation of experience, as well as through mentoring, coaching, and the correct resourcing strategy; this is also supported by the literature [1, 9, 24]. Resourcing strategies should allow resources to be placed on different types of projects and projects in different stages of the project lifecycle. The tacit knowledge context that is created

through training and experience will support the full use of organisational explicit knowledge. The organisational policies and procedures required to ensure that this context is created within the respective resources is the responsibility of the organisation itself, and specifically of management. The motivation to mentor another resource is a personal attribute, and is underpinned by a learning culture in the organisation. The importance of a learning culture was emphasised by the respondents, and is well-documented in the literature [1, 2, 10, 19, 24, 26].

“One has to be exposed to knowledge within certain contexts, thus gaining experience and accumulating knowledge... It would be better for the young engineer to work with the more experienced senior project manager on the same project [so that the project manager can] lead this person through the stages... you have to start off with experience in the different disciplines...” (Respondent 3)

“You are better off with the B team players working together as a team with individualistic A-team players. Just remember you also can’t play with the C team as the team in totality has all the tacit knowledge.” (Respondent 5)

“The project team must also be able/knowledgeable. If the project team does not have enough experience, a percentage of the knowledge/lessons will be lost because the individual cannot yet comprehend the context.” (Respondent 8)

4.1.3 Tacit knowledge

The respondents concurred that to improve access to tacit knowledge, resources should build and maintain quality networks within and outside one’s own organisation. Networks must include subject matter experts and be available to all resources. Tacit knowledge transfer also takes place between members of the team, and thus the composition and synergy that the team creates will benefit the organisation.

“...you must look at it from different points of view...” (Respondent 5)

“You might know something, or even a lot about the subject, but someone in the team will know something else or in addition to this.” (Respondent 6)

The organisational structure, culture, and governance process have an impact on the success of KM [10, 19, 28]. The governance processes should not restrict the flow of knowledge.

“These are all focused on bigger projects, resulting in challenges to set up something for small projects, as each is very different and specific to the project. But as long as the governance process is not too restrictive... [it] can very well be whittled down into usefulness... There are department heads... on the outside... responsible for new contracts, to do the initial project and process development work and interface with the project development group. The project development group forms the core of the business and deals with execution, detail design engineering, quality control, and specification write-up. This interface and transfer of knowledge seems to be a problem from time to time due to different focus and objectives.” (Respondent 1)

4.2 Knowledge transfer mechanisms and processes

The next section in the Delphi questionnaire aimed to reach consensus on knowledge transfer mechanisms and transfer processes that pull knowledge into the organisation.

4.2.1 Knowledge transfer mechanisms

The respondents emphasised the importance of the institutionalised-codification mechanism, and elaborated on this. The transfer mechanism includes codification mechanisms that are institutionalised in the routines and structures of the organisation, after which the codified knowledge is available to the entire organisation. This mechanism involves using formal organisational processes to update the current execution methodology, work flows, procedures, processes, and templates. A value assurance step ensures that the knowledge improves the current knowledge base. The centralised function or relevant resources determine whether this knowledge should be used to update specific processes, procedures, work-flows, execution methodology, templates, check-sheets, or training material. These documents should be readily available to the organisation as part of the knowledge database. The knowledge-pull framework denotes that the transfer mechanisms will depend on the size and geographical dispersion of the organisation. One

of the respondents indicated how a specific organisation's KM mechanisms changed as the organisation expanded.

"I did a project that was called the Quality Consolidation Project. We had a mandate to do the project. It was to take all procedures, work flows, and standards to review, give [it my organisational] branding, and implement. Resources did it in their own time. More than 70 per cent was approved and implemented in [the organisation's global execution methodology workflow database]. If a project updates a procedure and archives it with that project, then the new knowledge is only available to the people that worked on the project. For 50 out of the 60 years of existence, [my organisation] made use of knowledge transfer by people. The company had low turnover. This created a culture of learning. When you grow quickly, you do need a knowledge base as you don't have that same capacity anymore." (Respondent 4)

Formal transfer mechanisms should follow a value assurance step and be transferred into the organisational database. The resource that supplies the knowledge is responsible for codifying the knowledge and ensuring that it is disseminated. The centralised function will direct the actions and ensure that the processes are in place to receive this knowledge. With informal transfer mechanisms, the correct level of governance was discussed. The organisation should trust in the capabilities of the resources, in order to support the flow of knowledge. The organisation should also ensure that processes are in place to support both formal and informal transfer mechanisms, which will require different levels of quality control.

4.2.2 Transfer process

The concern considered by the respondents was localised knowledge transfer where the knowledge is not properly disseminated throughout the organisation. Organisations can employ a centralised function or identify specific positions in the organisational structure responsible for KM. The benefit of a centralised function is that these resources are able to identify trends based on the transferred knowledge, and determine the actions to be taken, based on the gathered knowledge and trends. The transfer of knowledge from the project team to this centralised function requires a specific formal or informal process to ensure that the knowledge will be transferred as part of the normal project execution process flow.

"... once you've completed a project, you go to the PMO [project management office] for 3-4 months to update procedures. This is required before you go to the next project." (Respondent 7)

"Due to the gap in the removal of the official KM group, the CoE [Centre of Expertise] started [a] lessons learned process and how to make the project management environment aware of it. We endeavour to institutionalise it and incorporate it in the official work processes." (Respondent 8)

"There must be a KM department that looks at the knowledge process of the organisation. Get people from outside that are experts in processes to do quality control." (Respondent 5)

"From these trends, it is then possible to make updates and recommendations to the bigger organisation." (Respondent 6)

"It is the project manager's responsibility to let the regional lead/director know that knowledge was created on his project." (Respondent 4)

Knowledge should not be directly transferred from the project to a database. The centralised function or relevant identified resource should evaluate the codified knowledge within the context generated throughout the transfer process, and determine how the knowledge should be used. This use can be the updating of a procedure, template, training material, or other formal organisation workflows and communications. The centralised function, acting as the organisational tacit knowledge base, will ensure that various projects have access to the tacit knowledge timeously and throughout the lifecycle of the project. The use of experienced resources will give the required context to the codified organisational knowledge.

From a different viewpoint, an attempt to incorporate all knowledge into the organisational database and processes will render these items unmanageable and cumbersome to read. An initial value assurance or quality control step is required to ensure that the knowledge is an improvement on the current knowledge base [29, 30]. If the knowledge is not an improvement, the value assurance

team can identify this and ensure that only the project team receives additional training on that subject, as this knowledge has value only for the specific project team. The value assurance team can also ensure that the project team is addressing the root cause of the problem. In addition to the formal knowledge transfer mechanisms, the respondents discussed the requirement for informal knowledge transfer. The mechanism should support timeous transfer from the knowledge source to the recipient. Company C outlined a smartphone application that the company was developing, making it possible for the company’s engineering design specifications to be accessed. Companies A and B make use of web-based communities of expertise: the website functions as a chat room where any employee can post a question and receive a response from an expert.

The transfer of knowledge from the project to the organisation means that there are many interfaces to take into consideration. As such, it is important to clearly define the roles and responsibilities of the project manager and project team, as well as those of the organisation. It is the project manager’s responsibility to identify, gather, codify, and transfer new knowledge, and it is the organisation’s responsibility to put processes and procedures in place as part of the normal project work flow, and to have resources available to accept this knowledge.

The important aspects from the respondents’ feedback that could aid in refining the initially proposed knowledge-pull framework are as follows:

- **Value assurance:** Ensures the quality of the explicit organisational database. Organisations should focus on both technical and organisational knowledge transfer. A centralised KM function (that assists in completing the value assurance step) builds a centralised tacit knowledge base that each project has access to. The knowledge can then be built back into the capital (or project) structures.
- **Centralised function:** The focus of new knowledge gathered is not on producing documents to be submitted into a database, but rather getting to the root cause of a problem and implementing a permanent solution to the problem by updating processes and procedures. The context of the knowledge remains paramount, and the centralised function will be able to provide context to the organisational codified knowledge base. This function will also govern the quality of project execution.
- **Informal transfer mechanisms:** Knowledge should be captured and transferred timeously throughout the lifecycle of the project. The project team will also require knowledge from the organisation to be delivered immediately. This transfer will require the use of various technologies, such as Twitter groups and instant messaging, or applications with technical data. This process should depend on the capabilities of the resources, as the quality cannot be governed by a specific centralised function.

4.3 Knowledge required per project lifecycle stage

The types of knowledge pertinent to each project stage are outlined in Table 2.

Table 2: Knowledge required per project lifecycle stage

Stage	Knowledge required
Initiate	Interface with experts, options identification and elimination, cost and technical viability, commissioning and construction philosophy, scope definition clarification and context, control base, philosophy, plan on how the project should be approached, project setup, opportunity analysis, business evaluation, technical philosophy, sponsor mandate, business/ operational and market knowledge, problem definition, business structure
Develop	Process engineering and assurance, keep process intent as developed previously, design, ensure technical changes are feasible, adjust the execution plan according to project requirements, use of specification and standards are important, logistics, access, task duration, business case, business plan, business risk management, technology knowledge, contracting strategy
Implement	Freeze scope, project management knowledge, project execution plan, documentation required by the client, commissioning plan, construction strategy, contracting strategy, manage by objective, project governance, staff selected and trained, start-up modifications plan, quality control plan per contracting strategy, operational planning
Operate	Commissioning and stable business performance, project and business review, optimisation plan, business sustainability and improvement
Close	Site re-use and analysis plan, business exit strategy (resources and environmental and client considerations), remediate site and monitor plan, termination of contracts, financial close-out

The purpose of the Delphi study questions in this section was to obtain consensus on the alignment, if any, between knowledge required by the organisation and knowledge transferred from the project within each stage of the project. The assumption is that the organisation requires specific knowledge per stage; this could direct knowledge transfer more effectively and efficiently.

“First of all, one determines what your scope is and set context, and then determine what is relevant for that stage. It is important to understand the risks of each stage, although one should also look at execution [while you are still in the developing stage]... Each environment is different and relevant to the specific project... In other words, one should first start with the context, gather more info on the context as the project progress, and then gather the relevant info to validate what you are doing. The level of detail increases [as the project progresses].” (Respondent 2)

“Once you go over to the next gate, your focus will shift. At Gate 5, the focus is on commissioning. Then you can't design. You must understand and determine the specific deliverables for the project. It is important to complete all the work within that stage before moving on, and complete only that work [within the specific stage].” (Respondent 3)

Based on the discussions, it was determined that the focus of the respondents is on capturing the knowledge, the process, and the resources used to complete this action, and the retention of context from the specific project rather than the specific project lifecycle stage.

“Continuity is very important. If you have people working only in one stage, you will have blinkers on. You must understand the system as a whole and your role in the total project... All resources should know about the entire length of the project, as well as the breadth of the project, the detail of each stage for each track.” (Respondent 3)

Although the respondents outlined specific knowledge relevant to each project stage, the focus should not be on dictating the knowledge required for each stage. This will not direct the knowledge transfer. The specific project, scope, and risks should be understood and the critical objectives and deliverables should be established for the specific project, per project stage. The project team should complete all and only those deliverables pertinent to the stage. Quality control or value assurance should be completed per deliverable against specific requirements based on the context of that project. The resources completing the value assurance or quality control should have the correct attitude, experience, and knowledge.

4.4 Dissemination and organisational improvements

One of the questions in the Delphi study was related to how one can determine consensus on the dissemination of knowledge throughout the organisation. For the knowledge to be pulled into the organisation, the knowledge transfer process should be followed from the project up to where the knowledge is again available for the next project [40]. There should be a good balance between letting the organisation know about the new knowledge and knowledge overload.

“In the proposals stage, the research must be done to determine what projects have been completed. Once this is established, the previous project's information is shared and sent to the new project...Marco Polo effect.” (Respondent 1)

The respondents agreed that dissemination of knowledge requires a receptive audience. Project teams are most susceptible at the beginning of each project stage. Use of the organisational database and the search for knowledge within the organisation should be supported by management actions. It is important that management enforces the KM system. This is possible either through reward or incorporation of this requirement into the organisations' performance appraisal system, which is embodied in the key performance indicators (KPIs).

“The problem is that communication via emails is unsuccessful, as one's current reality does not make you susceptible for info on other aspects other than what you are busy with... The question is if it is not more effective to have continuous training sessions... I've found through experience that formal training sessions are not effective. What did work well, was to receive information before a scheduled session with experienced people. This experienced person presented a specific topic, explained the topic with specific reference to concrete, current examples, thus eliciting questions and communication, resulting in comprehension.” (Respondent 8)

The important aspects from the respondents' feedback that could aid in refining the initially proposed knowledge-pull framework are as follows:

- **Personal networks:** The project team is most susceptible to new knowledge at the beginning of a stage, and as such, this is the optimal time to transfer knowledge. It is important also to create context through the use of personalised knowledge transfer. An optimal way to transfer knowledge is through project team workshops with resources who have completed similar projects previously.
- **Electronic media:** Communication tools such as e-mails, discussion groups, and blogs should also be used for knowledge dissemination.
- **Organisational processes:** Training sessions in small groups will elicit discussions, which have been shown to support internalisation of knowledge.

In order to pull in knowledge from the project, the organisation should have absorptive capacity and be receptive to the knowledge [8, 15, 28].

"It is the responsibility of the organisation to create a hold point at the end of each stage of the project, to do the quality management, and to update the explicit knowledge base of the organisation with relevant new knowledge that was created, if any. The person that will complete this action is the type of person that the project manager looks up to. The person will treat you with respect and give good feedback and uplifting criticism. This will motivate project managers." (Respondent 5)

The organisation should ensure there is a structure and work processes in place to receive knowledge from projects. Apart from the learning culture required within the organisation, a culture of trust is also required [2, 26, 41]. Organisational trust in employees' capabilities perpetuates open communication. An open communication platform will support real-time knowledge transfer as it is learned and required. Factors that motivate project managers to take the time and energy to complete and take part in the KM system include first-hand knowledge of the benefits of KM, seeing how the knowledge transferred was used, and experiencing the organisations' reaction to the communicated knowledge.

The organisation must be set up to motivate, guide, and ensure knowledge transfer, and give a definitive framework of where and when this should happen.

5 AN UPDATED AND REFINED KNOWLEDGE-PULL FRAMEWORK

Information from the first round of the Delphi study supports three learning processes, as outlined by Zollo and Winter [18] and as incorporated in the proposed framework. The framework outlines how knowledge is gathered by resources. Once knowledge is gained, it should be packaged and transferred to the organisation. Figure 2 highlighted the requirement for the packaging of information in general. From the Delphi study, it is clear that the formal and informal flows of knowledge should be managed separately, and this will dictate how knowledge is packaged and transferred for efficient dissemination. Transferring knowledge that requires institutionalised or formal mechanisms is achieved through codification, which creates an additional and more in-depth opportunity for sustained learning. This mechanism also requires a value assurance step and interface with the central KM function. The purpose of this transfer process is to incorporate the knowledge into the organisation on a permanent basis as part of the inherent processes, workflows, or execution methodology, which are also known as the organisational routines. Knowledge transfer through individualised or more informal mechanisms requires timeous or real-time interaction with the proposed audience, and less governance. This knowledge is packaged in a different way, also using a different technology. The focus here is less on permanence and more on the speed with which the resources can connect and exchange tacit knowledge.

The transfer mechanisms outlined in the knowledge-pull framework rely on the mechanisms proposed by Boh [3], which in turn depend on the geographical dispersion and size of the organisation. The consensus reached from the Delphi study supports the transfer mechanisms proposed by the literature [3, 20]. The Delphi study also highlighted the requirements for a value assurance step prior to incorporating the knowledge into the organisation. This is specifically required for formal transfer mechanisms. Informal knowledge transfer mechanisms should receive

less governance to support the timeous flow of knowledge. Here, the organisation must trust and rely on the capabilities of the resources for quality control.

The Delphi study indicated that the knowledge-pull framework in Figure 2 should be updated to incorporate two main knowledge transfer flows. The formal transfer mechanism will transfer knowledge through the value assurance step into the organisation. The informal knowledge transfer mechanisms will flow directly between the organisation and the project. It is proposed that the knowledge transferred by institutionalised- and individualised-codified mechanisms should first flow through the value assurance step before being incorporated into the organisation. Knowledge transferred via individualised-personalised transfer mechanisms should flow freely between the project and the organisation. Institutionalised-personalised mechanisms should either be transferred freely or through the governance step, depending on the knowledge transferred.

The first round of the Delphi study highlighted the requirement that the flow of knowledge back to the project should also be incorporated when considering a knowledge-pull framework. This requirement significantly influences the setup of the framework to pull in knowledge. The literature indicates that knowledge transfer to the organisation does not necessarily lead directly to its use; but its use is necessary if it is to be of benefit to the organisation [9, 10, 14]. The respondents specifically mentioned workshops that should take place at the start of each stage. During this workshop, similar projects and subject matter experts or the KM function should transfer tacit knowledge and create context for the explicit knowledge available to the project team. This will ensure that knowledge is disseminated at the correct moment, when the project team is receptive. The knowledge transferred is pertinent to the specific project and can lead directly to the improved execution of the project. As the project team directly benefits from this knowledge, they will be motivated to make use of the process. A KM culture and management focus will support the participation and input of the relevant stakeholders in the workshop. The initial proposed framework was updated to incorporate the flow of the knowledge back to the project, as shown in Figure 3.

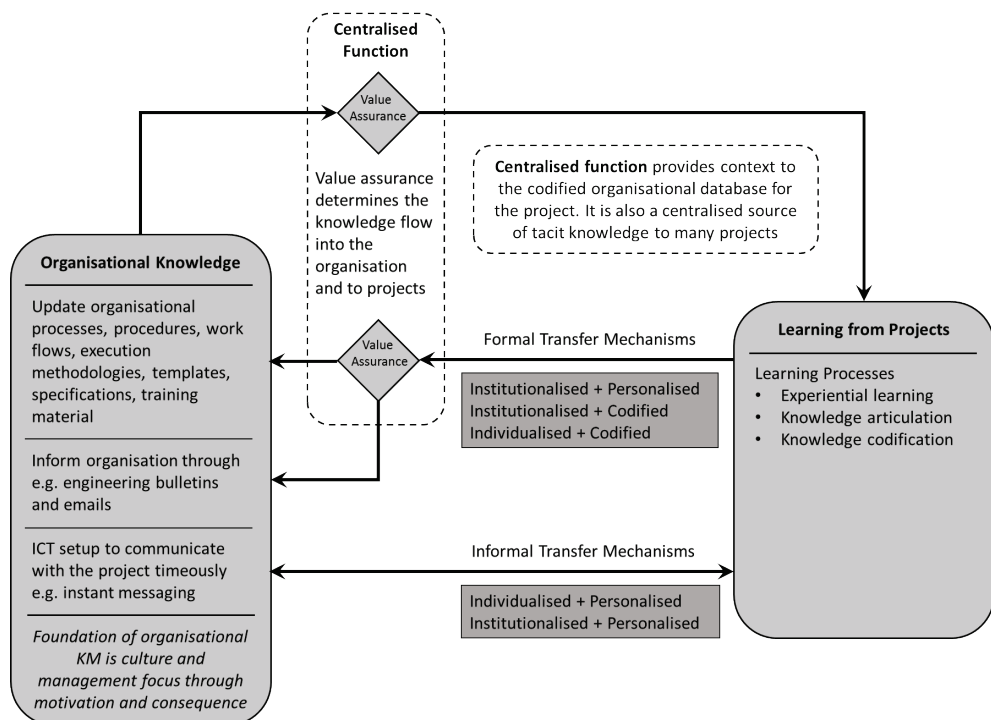


Figure 3: Updated and refined knowledge-pull framework

The focus of the proposed framework outlined earlier in Figure 2 is on the knowledge to be transferred from the project to the organisation, and does not include the flow of knowledge back to the project. In order for the organisation to pull in knowledge, it was proposed that the organisation should specify what knowledge is required during each stage of the project. The organisation should develop a database of experts to create the required context for the

organisational codified knowledge. The knowledge that is pulled into the organisation is then disseminated throughout the organisation.

The assumption that knowledge will be pulled into the organisation if the organisational procedures dictate specifically what knowledge is required per project lifecycle stage was contradicted in the Delphi study results. The focus on the knowledge required per project stage is required, instead, in the course of knowledge being transferred back into the project, with the input of the centralised function.

Based on the results of the Delphi study, the proposed framework was updated to include additional detail about the dissemination of knowledge in the organisation. The knowledge transfer mechanism influences how the knowledge should be disseminated throughout the organisation, within the organisational knowledge context, as outlined in Figure 3.

The proposed framework shown earlier in Figure 2 includes a requirement that the organisation should develop and maintain a database of experts in order to support the dissemination of tacit knowledge within the organisation. Based on the Delphi study results, a more structured approach is required. The centralised function or specific KM resources determine how the knowledge should be codified and disseminated. During this process, the KM resources determine how best to capture the depth of knowledge required. The organisation's project execution methodology should outline the requirement for a workshop at the beginning of every stage. The execution methodology then creates the opportunity for KM resources and specific subject matter experts to transfer tacit knowledge to the receptive project team. The organisational ICT platforms should also be set up in a manner to give resources direct access to experts, for example by creating a specific community of practice and expertise. The project or resource that requires the knowledge has direct access to experts in a specific field. This platform is automatically updated by having expert members in the community, negating the requirement for a separate expert database that is rarely updated.

The importance of the correct KM culture and management focus was not captured in the earlier proposed framework. Based on the results from the Delphi study, the framework was updated to include this element as a foundational one.

6 RESULTS FROM DELPHI ROUND TWO

The second and final round of the Delphi study consisted of a questionnaire containing the summary answers to each of the first round's questions, as well as the updated and refined knowledge-pull framework shown in Figure 3. Additional space was provided in the framework for comments by the respondents. Four responses were received; one each from Companies A and B, and two from Company C. The respondents were all in agreement on the summary and framework, with only minor additional comments.

One respondent disagreed that the knowledge captured by the project should be stage-specific. The respondent noted that it is important that the project first establishes lessons learned from other projects for the specific stage before continuing. This indicates support for the often-used practice of closeout meetings at the end of each project phase to capture knowledge gained during a project, in order then to transfer it to other projects. However, using knowledge from a similar stage of another project does not preclude the use of knowledge from other stages of other projects. Another comment on the knowledge-per-stage topic indicated that the focus of the knowledge to be shared is not so much on the specific stage, but rather on the context of the knowledge. The context should be created at the beginning of each project stage when the project team is most receptive. Pertinent knowledge should be repeated at the beginning of each stage, in order to ensure that all new stakeholders and project team members are also aligned. The framework does capture this.

Another respondent highlighted specifically the requirement for easy access to organisational databases. The respondent was of the opinion that resources in general are capable and should be trusted to know what knowledge is applicable. The respondent also advocated the use of instant messaging and online discussion groups to facilitate informal knowledge transfer, and suggested that organisations should make more use of these forums to disseminate knowledge.

With the respondents' support for the framework, and the summary of the concepts and workflows that support the framework, it was concluded that no further Delphi rounds were required.

7 CONCLUSIONS AND RECOMMENDATIONS

Based on a literature study and pilot questionnaire for the Delphi study, a conceptual framework was developed that shows the pull of knowledge into the organisation. The completed Delphi study supports the frameworks proposed by Boh [3] and Argote [16], while additional information pertinent to the process was captured as a result of the Delphi study process. Specific key words, phrases, and summarised outcomes of the Delphi study results necessitated an optimised and expanded knowledge-pull framework.

The framework in Figure 3 was developed based on the findings from the literature that one of the main contributing factors to knowledge transfer is the ability of the organisation to absorb the knowledge. The organisation aims to update its knowledge database or intellectual capital with the learning that occurs within each project. The research question about which transfer mechanism should be used was phrased to contextualise this point of how knowledge is transferred to the organisation. It was found from the Delphi study that there are different requirements for formal and informal knowledge transfer, and that this will impact the transfer mechanism used. The organisational KM system should be set up to manage and allow for both formal and informal transfer mechanisms. The utilisation, validation, incorporation, and communication processes, as well as the responsible resources and recipients, should be clearly determined within the organisation.

The research question about where the knowledge should be transferred to was phrased within the context of what the structure and functionalities of the database should be. The requirement for a searchable, accessible database was found in the literature and echoed by the Delphi study results. However, the main finding of the Delphi study was that the knowledge should be transferred to people rather than directly to a database; thus knowledge should be transferred to the resource people in the centralised KM function. These resources will determine whether the knowledge will be used at all and, if so, how. This optimises the updating of the knowledge database and organisational specifications, templates, processes, and procedures. These resources should also identify recurring trends to detect specific knowledge gaps within the organisation. A 'lessons learned' document should therefore not be simply communicated and transferred to a database. The root causes of problems related to the lessons learned should be determined, and the relevant action taken, as dictated by the KM function, such as updating or improving the relevant procedure.

The organisation should be both structured and motivated to receive new knowledge, incorporate it, and disseminate it throughout the organisation. The knowledge codification and transfer in this proposed way then becomes part of the normal project execution methodology, as well as part of the normal operation in the organisation. In addition to making it part of the project and organisational routines, effective KM also requires management focus and a learning culture. KM should be clearly encouraged, rewarded, and driven by management.

The aim of the research question about what knowledge is required per project stage was to determine whether this type of definition or specific requirement will aid the project in transferring suitable, value-adding knowledge to the organisation. It became clear from the study that the focus should not be on the specific project stage, but rather on the context of the specific project. Governing the specific knowledge required per stage will not pull knowledge into the organisation. The focus should rather be on the context of the specific project, the setup of the project deliverables, and the execution plan, in order to support a successful and efficient project execution. During project initiation, the codified knowledge base of the organisation (in-house execution methodology, work-processes, and templates) and the personal networks of experts and project teams who completed similar projects are used. The project is then governed against the specific deliverables and quality plan set up by the project team. The centralised KM function or value assurance team can ensure that the project supplies quality deliverables, validated within the context of the specific project, against the deliverables defined for the project for that specific stage. The project team is responsible for gathering the knowledge as they proceed through the lifecycle of the project. The centralised function (or similar resources) are responsible for receiving the knowledge and representing the gateway to the organisation's KM system.

Based on the literature review and Delphi study results, the following key recommendations were identified throughout the development of the knowledge-pull framework:

- The main focus of the dissemination process should not be centred solely on the functionalities of the database. The focus should rather be on how the knowledge can be incorporated into the project work-flow as an updated process, template, or specification.
- A centralised value assurance step is required before knowledge is incorporated into the current knowledge database. This is required for both technical and organisational knowledge.
- The centralised function responsible for value assurance of the knowledge is also responsible for value assurance on the project. Project deliverables should be validated against pre-determined requirements. This ensures that the project will be able to use the knowledge gathered on similar projects to update project-specific deliverables and procedures. Although a centralised function is required for receiving knowledge, project-specific updates should be decentralised.
- The centralised function should be responsible for transferring relevant knowledge to the new project team at the beginning of each stage during project or stage initiation. The project team should drive the process, and the organisation must make the centralised function available.
- Organisational and physical interfaces should be minimised; otherwise they can restrict knowledge flow.
- The organisation should perpetuate a learning culture and discernibly support KM.

Future research will assist in understanding the impact of the organisational KM structure on the efficacy of the framework. Such studies should also take into consideration the specific roles and responsibilities of the relevant stakeholders. The effect of value assurance on KM should be explored in further studies. Another potential research subject could be the direct effect of transferring pertinent knowledge back into the project, rather than considering dissemination in general.

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