IMPROVING KNOWLEDGE TRANSFER PROCESSES TO ADDRESS SKILLS AND KNOWLEDGE GAPS BETWEEN SENIOR AND JUNIOR STAFF IN ENGINEERING PROJECTS

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ABSTRACT

Skills and knowledge gaps between senior and junior staff is prevalent in engineering projects. This study aimed to identify the factors that affect knowledge transfer and methods to retain transferred knowledge between senior and junior staff in the South African engineering environment. Although several studies have examined the factors that influence knowledge transfer, very few have studied the factors affecting knowledge transfer between senior and junior staff in engineering projects. This study found that knowledge transfer is not made a priority in projects, and that there is a lack of knowledge transfer platforms and structures in projects. Incentivising knowledge transfer by making it a work outcome would improve knowledge transfer in projects.

OPSOMMING

Kennis- en vaardigingsgapings kom al hoe meer voor tussen senior and junior personeel wat op ingenieursprojekte werk. Hierdie studie het ten doel om die faktore wat die kennisoordrag tussen senior en junior personeel in die Suid-Afrikaanse ingenieurs omgewing belemmer, asook die metodes wat dit kan behou, te bepaal. Heelwat navorsing is reeds gedoen op die faktore wat kennisoordrag in die algemeen beïnvloed, maar min van hierdie studies spreek die faktore aan wat vir die kennis oordrag tussen senior en junior personeel in ingenieursprojekte geld. Hierdie studie het bevind dat kennisoordrag nie as ’n prioriteit binne ingenieursprojekte beskou word nie en dat daar ’n tekort aan kennisoordragstrukture en -platforms binne projekte bestaan. Verder is bevind dat die kennisoordrag binne projekte verbeter kan word indien dit aangespoor kan word deur dit deel te maak van die prestasie uitkomste van projekte en individue.

1. INTRODUCTION

Knowledge transfer is the procedure by which knowledgeable staff share or dispense their knowledge, behaviours, and skills to others around them [1]. The skills and knowledge gap referred to in this study is the differences in abilities and experience between senior and junior staff in engineering projects. The skills shortage in engineering is a major problem facing the public and private sector, and it is threatening the country’s ability to maintain, develop, and refurbish infrastructure [2]. The underlying skills and knowledge gap between senior and junior staff needs to be improved to decrease the loss of engineering capacity through retirement and emigration [3]. The major focus of this study was to investigate those skills and knowledge gaps by identifying and examining the barriers/factors that affect knowledge transfer processes between senior and junior staff in engineering projects.

It is common for senior employees to have more knowledge and experience than junior employees, and so senior staff must take initiatives for transferring knowledge to junior staff in a short period. The knowledge that senior staff have gained through their experience of working in projects will be lost if it is not transferred before they retire or leave the organisation. Thus, the study mainly focuses on investigating

ways to improving the knowledge transfer process in order to mitigate the issue of skill and knowledge gaps between senior and junior staff.

The research questions for this study were:

- What are the factors/barriers that affect knowledge transfer between senior and junior staff in engineering organisations?
- How can these factors/barriers be overcome in order to decrease the skills and knowledge gaps between senior and junior staff?
- What methods can be used to retain the knowledge transferred between senior and junior staff in engineering projects?

Reducing the skills gap between senior and junior employees would allow junior staff to demonstrate greater technical and process knowledge, which will lead to better work performance. Any organisation that fails to identify the pertinent skills gaps in its workforce can expect to encounter various problems in the workplace that might adversely affect the equilibrium of the workflow [4]. Hence, senior and junior staff should know how to share their skills and knowledge to work together to perform projects in the public and private sectors.

2. LITERATURE REVIEW

Engineering projects sometimes involve a large number of team members, and a project's work content is often distributed between them. The team members need to coordinate with one another and to deal with any issues in the projects that might arise in a relative short period of time because of the time constraints imposed on projects [5]. Furthermore, projects are regarded as an important source of knowledge creation; but the temporary nature of a project hinders the absorption of this knowledge in people, processes, and systems. Thus, there is a knowledge and skills difference between team members because the necessary knowledge and skills are not sufficiently transferred [6]. In order for junior and senior staff members to perform their roles and responsibilities, they need to develop their knowledge transfer skills to help them carry out their duties efficiently and effectively.

2.1. Skills gap overview

As a country, South Africa has experienced a loss of skilled people through emigration, leading to skills gaps [7]. Over time, the science and technology industry has experienced a major transformation through new technology, which has led to huge variations in the engineering sector [3]. Engineering projects also have tacit knowledge that can only be transmitted through knowledge transfer between senior and junior staff.

According to Ramadi, Ramadi and Nasr [8], gender discrimination in such areas can also contribute to a lack of capable employees in this sector. When there is gender discrimination, people of a gender group might not be given the job, which leads to a group of capable prospective employees being excluded. This form of discrimination causes skills gaps because the gender group might not be seen as able to perform the work, which decreases the pool of potential employees to choose from. The gap in skills can have a major impact on the engineering project outcomes, such as increments in time, money, risk factors, and potential litigation [8].

As observed by Brunhaver *et al*. [9], it has been found in a survey that 40% of the employees working in engineering projects feel that they are not appropriately skilled or trained for the roles that they have been assigned. To identify the skill gaps, it is essential to analyse the skills that are the most important in such roles. These skills then need to be developed in both junior and senior staff members with the help of appropriate professional development.

According to Thompson [10], the longer that skills gaps are present, the more in demand those skills become in the organisation. According to Slagter [11], the skills and knowledge gap will become larger as more people retire, and it takes time and money to replenish. Given the time lag to train new people and the level of demand for the skills, companies will experience shortages in the technical field. There might also be long recruiting times for these technical jobs because there are not enough qualified professionals to do them. It takes time for junior staff to reach a certain level of experience in engineering projects, and

an improved knowledge transfer process between senior and junior staff would help to close the skills and knowledge gaps. Identifying the factors/barriers to knowledge transfer would aid in closing those gaps.

2.2. Overview of skills in engineering projects

Engineering projects work with design processes, which need to use new technological systems and software to optimise current designs. As argued by Riaz, Attaullah and Mahboob [12], engineering project team members need advanced problem-solving techniques and proper communication. These skills are very important, and need to be addressed by senior staff members when training junior staff so that the junior employees develop these skills to perform their responsibilities.

Several skills are important in engineering projects team members. These can be divided into the technical and the soft skills that could be adopted to enhance the efficiency of projects [8]. A skilled engineer must have technical skills in mathematics and physics that help them to identify and solve complicated engineering issues [13]. Soft skills such as effective communication, leadership, commitment, and analytical thinking are also important in engineering projects [14]. All of these skills are necessary in both the senior or experienced employees and the junior or inexperienced members who work in various engineering projects.

As suggested by Clear *et al*. [15], soft skills have been lacking in the engineering sector: staff are not provided with the required training, and so miss opportunities to develop their professional capabilities. Owing to the skills gap, junior staff hesitate to ask for assistance from their senior colleagues, which gives rise to communication gaps among those who work in engineering projects [15]. The skill gaps that are present in junior or newly acquired staff need to be filled with the help of proper training and development. The most effective way to train new engineers is through on-site training programmes [16].

There are certain skills that would be valuable in the successful execution of engineering projects. Professional and technical skills would allow employees to perform at the top of their professions by staying current with all the technologies that would benefit them, and allow them to perform their work more efficiently [17].

In the view of Entholzner and Reeve [18], another major skill that is essential in projects is judgement and decision-making. According to Tho [19], decision-making generally resides with the senior staff members in engineering projects; but it is also essential to make the decision-making democratic. This skill is an important skillset when considering engineering projects. As observed by Bertolotti *et al*. [20], this skill can be provided to junior staff members with the help of training and experience.

According to Meredith, Mantel and Shafer [21], critical thinking is one of the priority skills that are necessary for engineering projects. It helps individuals to analyse the strengths and weaknesses in a project through problem-solving, inference, and concept correlation. This particular skill could be gained by engineers with the help of substantial knowledge and experience [21]. According to Khalema, Van Waveren and Chan [22], this skill is mostly found in senior members of the workforce. Therefore, the responsibility of helping junior members to implement critical and logical thinking rests with the experienced employees. Junior staff members also need the determination to incorporate this skill to develop their efficiency in projects.

Complex problem-solving is a vital skill in engineering projects [23]. This is the ability of an individual to handle non-routine tasks, deal with ambiguous relationships, adapt to unexpected changes, and cope with multiple objectives [24]. Such a skill would help to identify the complex issues and to review the related information in order to develop and evaluate the options and implement proper solutions. These skills require proper technical knowledge; and by identifying the roles and responsibilities assigned to the junior staff, the senior staff could understand better how to improve these skills [14]. To overcome the issues that arise in projects, senior staff members need to adopt appropriate problem-solving techniques [15].

2.3. Evaluating the factors/barriers that affect knowledge transfer

The transfer of knowledge in an engineering project can entail risk to junior employees, whose willingness to accept the knowledge and skills relies on the trustworthiness they perceive in their seniors [25]. Despite the benefits of learning, certain risks might be associated with such engineering projects. The seniors might have some concerns that the junior staff members will eventually become competitors for their positions

[26]. Thus, it can be said that the transfer of knowledge between senior and junior staff could be beneficial – but it could also give rise to a situation in which they are potentially vulnerable to one another. This in turn could contribute to the knowledge gap in a project. Investigating the factors and barriers to knowledge would help the role players to understand the reasons for the knowledge gaps between senior and junior staff.

The term 'personal barriers' refer to the general lack of time people take to share knowledge or to identify colleagues who have specific knowledge. Differences in educational levels might also be a personal barrier, along with a lack of trust in the people involved, as many individuals tend to misuse knowledge and to take unearned credit for it [27]. Personal barriers are also understood to include differences in ethnic background and national culture, along with the beliefs and values related to the individuals' languages [27].

Jin, Shu and Zhou [28] state that "[a] lack of managerial direction and leadership for clear communication of values and benefits can impact on the practices of sharing knowledge". If an organisation does not provide a system of recognition or rewards, employees might not get motivated, and this could influence the knowledge-sharing process.

Some other factors that impact knowledge transfer are mentioned by Prinsloo, Waveren and Chan [29]. A summary of all the barriers/factors that impact knowledge transfer is given in the table below, with references.

Table 1: Hindrances to the application of knowledge transfer

Factor	*Description*
Trust [30] [31] [32] [33] [34]	There needs to be trust in the source of knowledge as well as trust that the knowledge has the ability to have a positive impact.
Time [34]	There might not be enough time to apply the knowledge, as there is limited time to complete the task.
Maturity of knowledge [34]	The knowledge needs to be used for a certain period of time to instil confidence that it will have a positive impact.
Understanding of knowledge [35] [36] [32] [33] [34]	It is important that the receiver of the knowledge has the capacity to understand and interpret the knowledge being transferred.
Complexity of knowledge [34]	Sometimes the knowledge is complicated because it is not properly explained by the source; if the receiver does not understand the knowledge, it cannot be used.
Articulation of knowledge [34]	This refers to the formation process to make the knowledge more explicit and less tacit; otherwise, the receiver might find it difficult if they are not convinced about how it is formed.
Source of knowledge [36] [37] [34]	The source needs to be confident in the knowledge being transferred, if the source is not confident, the receiver will lack trust in that knowledge.
Explanation of knowledge [38] [39] [30] [34]	The source needs to explain the knowledge thoroughly when it is being shared, as this will increase the likelihood that the knowledge will be applied.
Content of knowledge [34]	This refers to the environment and situation in which the knowledge is shared, as some knowledge is only applicable in certain settings.
Usefulness of knowledge [6] [31] [40] [37] [34]	This refers to the outputs of the knowledge shared and how the knowledge has helped in improving the effectiveness and efficiency of a task or project.

2.4. Current theories and models

According to Dissanayake [41], early knowledge-transfer models perceived knowledge as an object that can be mechanistically passed on from the originator to the interpreter, who then adapts and transmits the data to a user. In the process, users have generally been perceived as knowledge receptacles (passive actors), while the context of the transfer process was ignored. Traditional knowledge transfer models assumed a hierarchical relationship between the knowledge generator (the person holding the knowledge – the resource) and the receptacle (the user), with the latter locked into a position of dependency [42]. Authors such as Meier *et al*. [43] have criticised such linear knowledge transfer models for disregarding the reality of generating new knowledge and using it.

According to Heisig [44], the six most common activities found in knowledge-management frameworks are identifying, creating, acquiring, using, sharing, and storing knowledge. This shows that these are the main activities that should form part of a knowledge-management framework. It has also been found that, for a knowledge-management framework to be successful, the following categories are critical: (1) human-oriented factors such as culture, people, and leadership; (2) organisational processes and structure; (3) technology processes such as infrastructure; and (4) applications and management processes such as strategy, measurement, and goals.

Liyanage *et al*. [45] maintain that, throughout the process of knowledge transfer, the knowledge transferred from the sender's end will inevitably change form, appearance, or shape at the receiver's end. There are four forms that tacit and explicit knowledge transfer can take: socialisation, externalisation, internalisation, and combination [45]. The four modes in which tacit and explicit knowledge can be transferred are shown in figure 1 below [46].

Explicit to tacit (**Internalisation**) e.g. learn from a report	**Tacit to explicit** (**Externalisation**) e.g. dialogue within team, answer and questions
Tacit to tacit (**Socialisation**) e.g. team meetings and discussions	**Explicit to explicit** (**Combination**) e.g. e-mail to report

Figure 1: Modes of knowledge transfer [46]

As a result, there is a need to interpret the altered knowledge carefully and in detail if the knowledge is to be effectively used by the receiver [47]. Cardoni *et al*. [48] state that, with such considerations, the knowledge transfer process entails six key steps.

Table 2: Key steps in the knowledge transfer process [48]

#	*Knowledge transfer steps*	*Description*
1	Awareness	The identification of where the correct knowledge can be found
2	Acquisition	Knowledge acquisition, providing that the source and receiver have the ability, resources, and willingness
3	Transformation	Knowledge conversion to make it convenient for the receiving party to generate fresh knowledge and/or to advance the prevailing knowledge, capabilities, or skills
4	Association	Recognising the likely benefits of knowledge by relating it to the company's internal capabilities and needs
5	Application	Using the knowledge to advance the capabilities of the company
6	Knowledge feedback/externalisation	Transferring the receiver's new knowledge to the source, or creating experiences and making the knowledge transfer process reciprocal

3. A CONCEPTUAL FRAMEWORK FOR KNOWLEDGE TRANSFER

This study developed a conceptual model to use as a framework to evaluate the barriers that hinder each stage of knowledge transfer. The model was derived from the dynamic knowledge transfer capacity (DKTC) models of Parent, Roy and St-Jacques [49] and Liyanage et al. [45]. The DKTC model of Parent, Roy and St-Jacques [49] portrays the knowledge transfer process as occurring in a system that has certain permitting capacities. It also identifies the components required by the social system to disseminate, use, and generate fresh knowledge and meet its own needs as the following: governments, researchers, communities, and practitioners [50]. The model of Liyanage et al. [45] divides the knowledge transfer process into several, which makes it easier to identify where in the transfer process senior and junior staff experience difficulties. Once the factors or barriers to knowledge transfer can be linked to the stages, it is easier to find methods to improve the transfer process. This study maintains that the receiver and the source are two crucially supportive objects of the knowledge transfer process. The term 'source' means the individual who is willing to undertake knowledge transfer (here, the senior staff member or mentor) with another person, while the term 'receiver' means the individual receiving knowledge about their role (the junior staff or mentee).

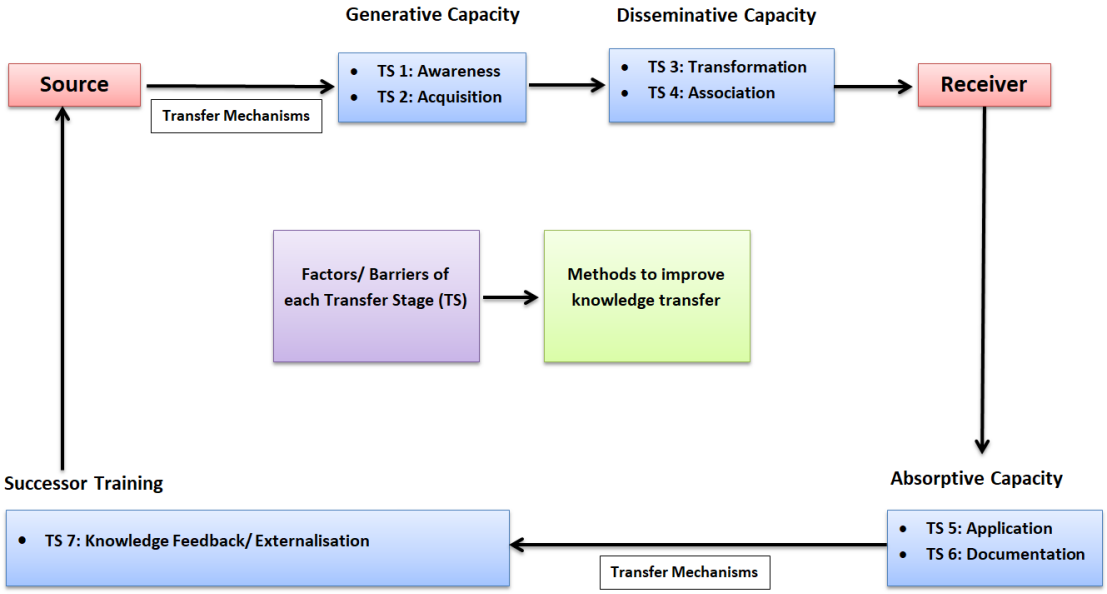

Figure 2: Proposed conceptual model for knowledge transfer

The awareness stage mainly focuses on the receiver finding out where the knowledge is or who is its source [45]. Knowledge transfer between a senior and a junior requires both parties to be aware of the importance of and need for the process when training or recruiting a new employee [51].

In the acquisition stage, knowledge transfer focuses on how the knowledge that is needed can be received from the willing parties who have it [45]. At this stage, the source should have the capacity to offer information and data about their work, both documented and verbal, because that would make it easier to find a replacement once they leave the company. The willingness to offer the knowledge source maximises the likelihood of knowledge transfer.

Knowledge transformation is where employees need to transform knowledge into practical aspects in order to implement it [52]. Knowledge theory reservoirs include the people, tasks, tools, and knowledge refineries (that is, the processes to distribute and create knowledge) and the roles of cross-functional management. Correspondingly, the DKTC model stresses particular activities to facilitate the accruing of experience, and knowledge codification and articulation. The knowledge transfer mechanisms include the simultaneous application of technology and people. In respect of knowledge transfer between senior and junior staff, knowledge and information should be properly provided to transfer knowledge by word-of-mouth or in the proper documentation [52].

The knowledge association stage is about identifying where the gained knowledge could be used. Before the knowledge can be implemented, its suitability to the junior employee, the organisation's need for the knowledge, and the urgency level of the knowledge must be identified [45]. The urgency level is how significant the required knowledge is, and how transferrable and implementable it is. Once this has been done, all junior or new employees must have the capacity to identify the potential benefits of knowledge transformation to meet the needs of the organisation.

Knowledge application is an important knowledge transfer activity. It works if there is transfer from a source to a receiver, and the knowledge is used or implemented [45]. The process of knowledge application is successful when the junior employee has a good understanding of or appreciation for acquired knowledge, and uses it to fulfil the roles and needs of the organisation. This can be measured through performance reviews, the quality of the work received from junior staff, and the time set aside by junior staff for research to complete the project.

Documentation is an important technique to retain the knowledge being transferred; and so it would be beneficial if junior staff kept some form of documentation to retain the knowledge that was transferred to them. According to Johnston [53], in a rapidly changing technical and scientific environment, only explicit knowledge is formally shared and documented. This could be in the form reports, journals, or other kinds of record keeping. This would allow junior employee to become sources of knowledge transfer, thus continuing the process in a timely and efficient way. This would also allow the junior employee to retain much more information from the knowledge transfer process.

Knowledge feedback/externalisation is when the receiver has fully assimilated the knowledge and becomes a knowledge source [45]. One of the ways to transfer knowledge at this stage is to provide junior employees with a training schedule. The training must benefit both the knowledge giver (the senior employee) and the junior employee (the recipient): it would allow the junior employee to become competent, while the senior employee would gain feedback on the transferred knowledge [52]. As a result, knowledge feedback or externalisation would enable the junior staff to attain good skills for new innovations and ideas in the organisation. In the long run, junior employees will replace senior employees when they depart.

4. RESEARCH METHODOLOGY

Semi-structured interviews were used because this was a qualitative research study. This method allowed the participants to answer questions in more detail. More data about the individuals' values, opinions, and attitudes could also be collected, and it allowed a more relaxed atmosphere that encouraged the participants to be honest and open. The study conducted the interviews with 30 personnel, who were engineers, engineering technologists, and engineering technicians at both junior and senior levels. Of the 30 personnel, 15 were junior and 15 were senior.

The study was conducted in one organisation. It was best suited for this study because it is a large organisation that works on many engineering projects of varying sizes, as stated in the table below. The organisation is part of the public sector, and deals with projects in housing and other projects in which they partner with the private sector. This gives the employees experience in both private and public sector projects, which can take anywhere from six months to several years to complete. The organisation's projects are also large and multidisciplinary in nature. This means that its employees work in different disciplines such as mechanical, electrical, electronic, and civil engineering. This allowed the researcher to obtain information from a diverse pool of respondents of different roles and levels in engineering projects who had a large range of years' work experience.

The data was analysed using ATLAS.ti, a Computer-Assisted Qualitative Data Analysis Software (CAQDAS) application. Content analysis for this study followed the methods in Morse and Niehaus [54]. Open coding was used by breaking down the data into parts and examining them closely. Open coding allows one to see the direction of the research and to focus conceptually on particular themes. This focus then allows the researcher to narrow down the relevance of the themes, thus allowing for a better grouping of similar aspects of the research.

Table 3 shows the demographics of the respondents with their designations in the organisation. They ranged from low-level to high-level personnel, with a large range of years' work experience.

Table 3: Demographics of respondents

Demographic	Detail
Current positions in organisation	• Chief director (1) • Director (2) • Chief engineering professionals (6) • Production engineering professionals (11) • Candidate engineering professionals (10)
Number of years' work experience	• Average: 23 years • Range: 4 to 42 years
Number of Senior and Junior employees	• Juniors: 15 (less than 7 years' experience) • Seniors: 15 (more than 7 years' project management experience)
Company size	• Large size (500 – 800 employees)
Number of projects running at a given time in the organisation	• Average: 20 projects • Range: 10 – 30 projects
Typical project size in the organisation	• Average: Large projects (take more than one year to complete; R20m) • Range: Small (months; R2m) to large (years; >R1b)

5. RESULTS

5.1. Factors/barriers that affect knowledge transfer between senior and junior staff in engineering projects

Below is a discussion of the data collected from the study, with respect to the factors or barriers that affect knowledge transfer between senior and junior employees in engineering projects. The knowledge referred to in this study was a mix of both explicit and tacit knowledge. Some of it began as explicit knowledge, especially in engineering design; but the application of the knowledge in different project systems tended to change the knowledge to being tacit in nature. Tacit knowledge gives the necessary background to structure, interpret, and develop explicit knowledge [55]. This shows that there is an inextricable link between tacit and explicit knowledge [45]. The factors/ barriers are linked to the knowledge transfer stages.

5.1.1. Knowledge transfer stage: Awareness

- *Knowledge transfer not a priority in engineering projects*: Very little or no importance was given to knowledge transfer within projects, as the completion of the project was the main priority for the organisation. In a project environment, the main objectives are production-based. One respondent said, "Knowledge transfer is not seen as a priority".
- *Fear owing to inadequacy of experience*: Sometime employees felt that they were not experienced or confident enough with the knowledge to share it with others. One respondent said, "Fear of sharing your ideas and your creativeness with others".

5.1.2. Knowledge transfer stage: Acquisition

- *Attitude of the junior or senior employee*: Some employees were not open to knowledge transfer, and they were not open-minded about it. Employees did not show an interest in knowledge transfer, and did not see its importance in projects. One respondent said, "When junior staff acts as if they know better than the senior staff, it is my experience that senior staff automatically retract from guiding the junior staff, as they feel their inputs are not taken seriously".

- *Seniors' fear of becoming redundant or risk of losing job security*: The senior employees felt that, if all their knowledge were transferred, they might be in danger of being replaced or lose their value in the organisation and become redundant as juniors take over. One respondent said, "Job security, and especially the drive to employ a younger workforce, may lead to senior staff not being willing to share all their knowledge with the junior staff in fear of being asked to retire early".
- *Lack of trust in the knowledge shared*: Owing to low levels of trust between employees, the junior/receiver did not trust the knowledge shared, and so would not use it. One respondent said, "Employees are concerned that knowledge may harm instead of help their career".
- *"Don't want to make it too easy for junior employees"*: Senior employees felt that they had to work hard for the knowledge they had gained, and that simply sharing it would reduce the problem-solving skills of the junior employees. One respondent said, "When junior staff is not willing to try to complete a project on their own and try to do research on a topic, the senior staff gets the impression that they want the easy way out".
- *Frustration about lack of guidance in the past*: Junior employees tried to avoid knowledge-sharing with senior employees because of previous experiences when there was a lack of guidance from them. One respondent said, "Frustration of the mentee due to lack of guidance and attention from the mentor".

5.1.3. Knowledge transfer stage: Transformation

- *Knowledge transfer platforms/structures not present in engineering projects*: There were no structure or platforms within the project to allow for knowledge transfer or to apply the knowledge. One respondent said, "it is about meeting deadlines and getting the job done".
- *Ability of the employee to receive or transfer knowledge*: Some of the knowledge transferred was at a higher level, and so junior employees had difficulty in grasping some aspects of it. One respondent said, "Some mentors and/or supervisors just do not know how to effectively transfer their knowledge to the junior staff"; another respondent said, "Junior staff don't have the capacity to remember and sometimes use knowledge shared".

5.1.4. Knowledge transfer stage: Association

- *The knowledge transferred conflicts with new the technology that is used, or is outdated*: Engineering has evolved a lot over the years. With new technology and some engineering practices – especially in engineering design – changing, knowledge from a few years ago becomes outdated and less relevant than it was before. One respondent said, "The knowledge conflicts with the way I have been trained at university, mostly due to technological advancements changing the way one generation does things in comparison to the way the older (mentor's) generation does things".
- *Personality, cultural, racial, and language differences between employees*: Human factors such as these tended to cause a divide and to impede the knowledge transfer process between senior and junior employee. One respondent said, "Seniors might have or at least think that they can only communicate to the juniors within their language, personality and cultural capabilities".
- *Generational gap between senior and junior employees*: The generation gap between the senior and junior employees led to a lack of common ground, which in turn led to difficulties in transferring knowledge. One respondent said, "Communication between people from different generations can become an obstacle when sharing knowledge".

5.1.5. Knowledge transfer stage: Application

- *Lack of relevant projects to transfer specific knowledge*: Some knowledge was project-specific, and not all projects required the specific knowledge. Thus there were not always relevant projects for the specific knowledge to be applied in a practical way. One respondent said, "There is a lack of relevant projects. Every project has different skills to teach. New skills and design concepts are best learned by implementing tasks and seeing them come into being".
- *Time constraint for knowledge transfer*: Not enough time was dedicated to knowledge transfer in projects because of the "production-based nature of engineering projects", said one respondent. The knowledge transferred was sometimes incomplete.

5.1.6. Knowledge transfer stage: Documentation

- *Insufficient documentation from which to retrieve knowledge*: The knowledge was not properly recorded. This created difficulties because employees could not refer back to it for clarity, which led to the knowledge not being used. One respondent said, "Lack of source material. In other words, many of the experienced engineers that I have come across do not have past resources that they can use for reference when they come across similar projects".
- *Loss of experienced employees*: A large number of senior employees had retired or left the organisation. They held large bodies of knowledge, and now that they were no longer part of the organisation, a large body of knowledge that should have been transferred had been lost. One respondent said, "Loss of team leaders or senior engineers with the greatest experience".

5.1.7. Knowledge transfer stage: Feedback and externalisation

- *Organisation not focused on knowledge transfer*: Not enough focus was put on the role of the organisation in knowledge transfer in projects. One respondent said, "Lack of emphasis on skills and knowledge transfer by my organisation".
- *Over-estimation of knowledge level of receiver by source*: Seniors employees sometimes overestimated the knowledge level of the junior employees, which led to their not fully understanding the knowledge transferred by the senior employee. One respondent said, "Lack of understanding of the knowledge level of junior staff by the seniors".
- *Knowledge forgotten through disuse*: Some knowledge had not been practised very often, which led to it being forgotten by the senior/source. One respondent said, "I am taught new skills and [they are] forgotten after a couple of years because I have not applied the knowledge learned".

5.2. Difficulties in understanding and applying the knowledge being transferred

The difficulties faced by juniors/receivers in understanding or applying the knowledge transferred to them by senior employees are mentioned below.

- Transferred knowledge is incomplete and without sufficient background
- Knowledge conflicts with new technology practices
- Low confidence in transferred knowledge
- Generation gap between senior and junior, leading to misinterpretation of knowledge
- Fear of wrong application of transferred knowledge
- Lack of flexibility/time given by seniors to allow the junior to assimilate the knowledge
- Base knowledge, education level, and technical experience of receiver overestimated by source
- Lack of relevant projects to apply knowledge
- Difficulty moving from technical to practical knowledge
- Misinterpretation of knowledge because of differences in background
- Insufficient knowledge transfer skills of the senior/source
- Lack of tools to demonstrate knowledge

5.3. Factor/barrier linked to each stage in the knowledge transfer process with respect to the conceptual model

The factors and barriers were linked to the knowledge transfer stages from the conceptual model in this study. The knowledge transfer process was divided into seven stages, as shown in Table 4 below. This was done to identify where in the knowledge transfer process senior and junior staff had difficulties. This, in turn, would indicate which areas in knowledge transfer needed to be improved in order to mitigate the knowledge and skills gaps between junior and senior staff. Methods to improve knowledge transfer were then linked to each stage of the knowledge transfer process, as shown in Table 4.

Table 4: Factors or barriers linked to each stage of knowledge transfer stage

Knowledge transfer stage	Factor or barrier	Method to improve knowledge transfer
Awareness	No proper communication about the knowledge gaps by juniors Seniors unaware of knowledge gaps Overestimation of base knowledge level of junior/ receiver by senior/source Junior/receiver not sure who has the knowledge (confusion about source)	Organisation should set up systems to monitor knowledge transfer within projects Create a system in which personnel are linked to their body of knowledge fields (source tracking)
Acquisition	Lack of skill in transferring knowledge to show its relevance Time not sufficient to transfer knowledge Attitude and willingness of junior/receiver towards knowledge transfer Employees tend to work in silos within projects Lack of trust in knowledge shared	Introduce training of employees to understand and transfer knowledge more efficiently Organisation should incentivise knowledge transfer Organisation should make knowledge transfer one of the project outcomes Team work could help to improve knowledge transfer and decrease knowledge gaps Juniors should organise think-tank sessions to engage with seniors Projects should have time allocated for knowledge feedback sessions Improve mentoring programmes and create opportunities for job shadowing
Transformation	The knowledge transferred conflicts with new technology No time taken by junior/receiver to assimilate knowledge shared Difficulty in moving from technical to practical knowledge Low confidence in the knowledge transferred	Seniors should find ways to adapt knowledge to new technology Level of trust needs to be built between senior and junior
Association	The knowledge transferred conflicts with new technology practices, or knowledge is outdated Knowledge transferred not fully understood	Seniors should find ways to adapt knowledge to new technology practices Allow juniors time to assimilate knowledge transferred
Application	Knowledge transferred is incomplete Knowledge transferred without showing relevance to current project Lack of relevant projects to which to apply knowledge	Knowledge needs to be linked to practical aspects for better retention Organisation can allocate juniors to projects that help to close their knowledge gaps

Knowledge transfer stage	Factor or barrier	Method to improve knowledge transfer
Documentation	Documentation is kept on centralised servers with limited access, and there is poor management of the servers. Poor management of network drives, and documentation storage not enforced in organisation Poor documentation from which to retrieve knowledge Knowledge documentation horded and not shared by individuals	Create knowledge repository to store organisation's knowledge Document knowledge to be obtained in the form of reports, training manuals, etc. Improve back-up and storage of information Discuss knowledge in visual and graphical forms Provide training for knowledge transfer in organisation Put in place proper management of knowledge databases Knowledge documentation should be enforced by organisation
Feedback and externalisation	Organisation doesn't provide platforms for knowledge transfer No systems in place to monitor knowledge transfer	Organisation should create more platforms for knowledge transfer in projects Programmes or systems needs to be introduced to monitor and evaluate knowledge transfer in the organisation

5.4. Mechanisms used to transfer knowledge between senior and junior employees

Table 5 below sets out the knowledge transfer mechanisms that could be used to improve knowledge transfer between senior and junior employees in engineering projects. The mechanisms would also be linked to the knowledge transfer stages where it could be used, from the proposed conceptual model derived in this study.

Table 5: Knowledge transfer mechanisms

#	Mechanism	Description
Awareness		
1.	**Link personnel to field of expertise (source tracking)**	A system that juniors can use to easily track who the body of knowledge is in certain fields. Some of the respondents mentioned that it was hard for junior employees to find out who had the knowledge for which they were searching; this system would help to mitigate this problem.
Acquisition		
2.	**Think-tank sessions**	This is when a group of experts (senior employees) meet regularly with junior employees to share knowledge of their respective fields. Some respondents suggested this as a way to improve knowledge transfer, but it was not being used in the organisation.
3.	**Knowledge-sharing sessions**	This is when employees meet to discuss lessons learned and problems faced in the projects they have done, to give feedback and share knowledge. This is a good way to retain knowledge in the organisation. Some respondents suggested this as a transfer mechanism, but this mechanism is used by only some units in the organisation. Those who do use this mechanism find that it works effectively to transfer knowledge.

#	Mechanism	Description
4.	**Mentorship programmes**	These are when senior employees are grouped with junior employees to guide them through their work, and allow for knowledge transfer between mentor and mentee. The respondents had different responses, but the main constraint was that the ratio of mentor to mentee was too high. The number of mentors (experienced) employees was very low compared with the number of junior employees, leading them to be overburdened and so unable to use this mechanism as effectively as it should be.
5.	**Work shadowing**	This is when junior employees accompany senior employees on current projects to observe the tasks, thus allowing the seniors employees to impart knowledge to the juniors in real time. The respondents said that this mechanism existed in some units, but was not used in others because of the time constraints of their work, and because some employees were not open to using this mechanism.
6.	**Knowledge transfer training programme**	Proper training programmes educate and train employees in knowledge transfer and its benefits. Some respondent suggested this as a way to improve knowledge transfer in the organisation, but this mechanism was not being used in the organisation.
7.	**Knowledge transfer monitoring programme**	Creating a programme or system to monitor the knowledge transferred by employees could improve the knowledge transfer process in organisations. Some respondent suggested this as a way to improve knowledge transfer in the organisation, but this mechanism was not being used in the organisation.
8.	**Project site visits**	These are when employees perform site visits while the projects are running to gain practical experience. The units that use this mechanism found it to be effective, but not all of them used it. One respondent said, “Site visits are a good way to integrate theory and practical knowledge”.
9.	**Team work**	This is when employees are grouped to perform certain tasks. A few respondents found this a good mechanism to ensure effective communication among employees.
10.	**Project presentations**	This is about presenting project outcomes and general information about projects to fellow employees once the project has been completed. A few respondents mentioned this, but it was not widely used in the organisation – only by some sections. Those who used this mechanism found it to be an effective way to transfer knowledge.
11.	**Social networking**	Creating social networking among employees would allow them to have better communication with one another, leading to their being more comfortable about sharing knowledge. This mechanism was not widely used in the organisation, but there were varying responses on its effectiveness. One respondent said, “[A] social media request mostly elicits a short reply, but this could allow work colleagues to build rapport among each other”.
12.	**Knowledge transfer initiatives**	Many of the respondents said that these initiatives were not common in the organisation, and were mainly dependent on individual employees. One respondent said, “Improving on more knowledge transfer platforms is needed in the organisation”.

Documentation

#	Mechanism	Description
13.	**Knowledge repository**	Many respondents mentioned the need for this form of documentation, but it was not being used in the organisation.
14.	**Intranet and network drives**	This is a communication network that is exclusive to the organisation, and is used for sharing information within the organisation. The general response of the respondents was that there were centralised network drives, but that these were not used because the management of these drives was very poor. One of the respondents said, "There is a central network; however, not always accessible or even freely available due to poor record keeping, maintenance, updating, storing, and there is no management of it." The researcher investigated the network drives, and found that the information was not organised, access was restricted, and the network drives were offline and unavailable at certain times.
15.	**Weekly/monthly meetings**	Varying responses were received on this mechanism being used for knowledge transfer, with some sections finding this effective, while other sections found it less so. In some units, meetings were not always held regularly.

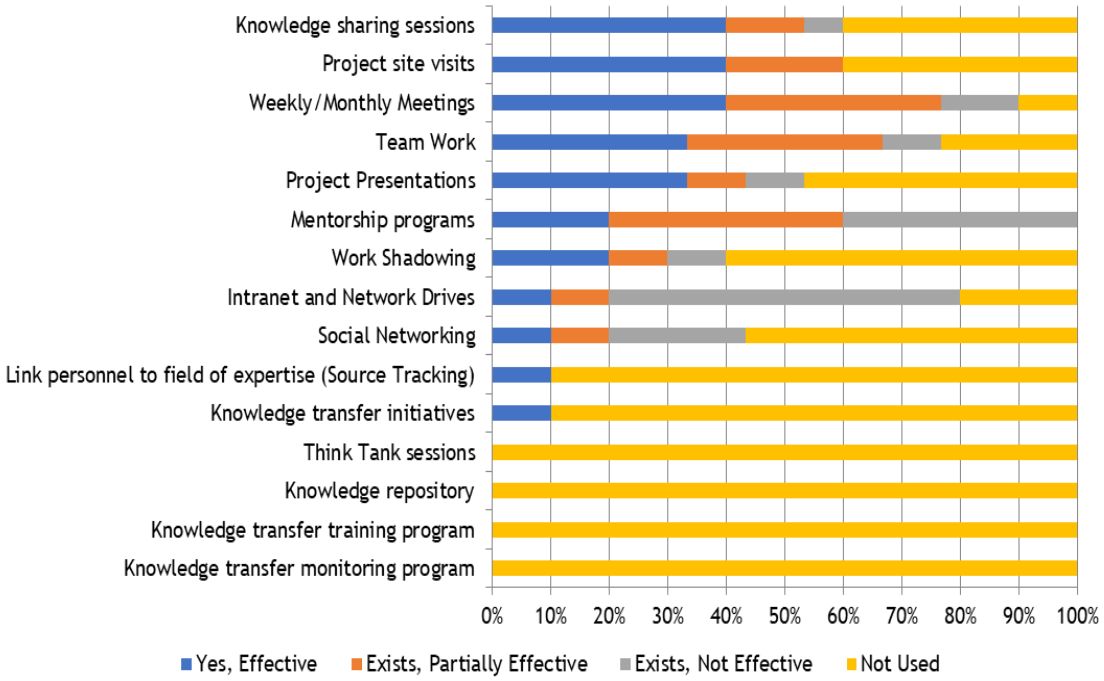

Figure 3: Knowledge transfer mechanisms used, and their effectiveness

Figure 3 above shows the different transfer mechanisms, links them to how effective each mechanism was, and indicates whether or not the mechanism was used in the organisation.

5.5. Tacit knowledge

This section discusses the tacit knowledge found in engineering projects. The kinds of tacit knowledge that hold the most value in engineering projects are listed below. A total of nine knowledge types were identified in this study.

- Heuristics (certain rules of thumb assumptions that seniors have learnt in projects)
- How to apply engineering judgement
- Communication skills and dealing with politics in work environment
- Problem-solving approach and handling of sensitive situations in projects
- Conversion from design to building of designs in projects
- Fault/error-finding approach in projects
- Selection process of personnel for certain project tasks
- Engineering project management
- Procedures used to gather feedback from personnel on design performance

6. CONCLUSION

This article focused on how knowledge transfer methods could be improved to close the knowledge and skills gaps between junior and senior employees in engineering projects. Knowledge transfer is the process by which knowledgeable employees share or dispense their knowledge, behaviours, and skills to the employees around them. There are currently skills gaps between junior and senior technical staff in engineering projects, and so this study investigated ways to improve the knowledge transfer process, which would help to close those gaps.

A new conceptual model was proposed using previous models of knowledge. The model divided the knowledge transfer process into seven stages: awareness, acquisition, transformation, association, application, documentation, and knowledge feedback/externalisation. This model was used to identify where in the knowledge transfer process senior and junior staff had difficulties; doing so showed which stages needed to be focused on.

The research questions for this study were:

- RESEARCH QUESTION 1: What are the factors/barriers that affect knowledge transfer between senior and junior staff in engineering organisations?

  The main factors/barriers that were found to affect knowledge transfer were the attitude of the employee, senior employees' fear of becoming redundant, and knowledge transfer not being a priority in engineering projects. New factors/barriers that were discovered in this study and that had not been identified in previous research were the source's fear of inadequacy in his/her knowledge; no proper documentation of knowledge transferred, thus making knowledge hard to retrieve; knowledge transferred by senior employees conflicting with new technology or being outdated; and the time constraint in engineering projects to transfer knowledge.

- RESEARCH QUESTION 2: How could these factors/barriers be overcome in order to decrease the skills and knowledge gaps between senior and junior staff?

  This study found that the ways to overcome factors/barriers in the knowledge transfer process included mentorship programmes, job shadowing, allocating time for knowledge transfer, creating platforms within the organisation for knowledge transfer, and training and motivating employees to take part in the knowledge transfer process. Ways in which these factors/barriers could be overcome, and that were not seen in previous studies, included having knowledge-sharing sessions within the organisation, creating a system to link employees to their field of expertise to allow better source-tracking of knowledge, incentivising knowledge transfer within engineering projects

by making it a work outcome, and creating monitoring processes in projects for knowledge transfer.

- RESEARCH QUESTION 3: What methods could be used to retain the knowledge transferred between senior and junior staff in engineering projects?

  Methods that were found in this study that could be used to retain transferred knowledge included having knowledge-sharing sessions within the organisation, and work-shadowing with senior employees, which would allow junior staff to retain knowledge. A proper documentation system would need to be created to retain the transferred knowledge in a formal way. Methods revealed in this study that were not seen in previous studies to retain knowledge included project site visits with senior employees, which would allow junior staff to retain knowledge better because they would see the knowledge applied; think-tank sessions within the organisation that would allow open dialogue between senior and junior staff; creating a knowledge repository within the organisation, thus giving personnel access – a form of storage for better knowledge retention; creating a knowledge transfer monitoring system; and training employees in efficient knowledge transfer skills.

Some of the limitations of this study were the limited availability of respondents and time constraints; the use of semi-structured interviews as an instrument for the collection of data; and limiting the study to one organisation because of time constraints.

The research contributed to identifying the list of barriers/factors that affect knowledge transfer between senior and junior employees in engineering projects. It also looked into ways to improve the knowledge transfer process and to retain the knowledge that is transferred. Taking into account the approach and the research design followed in this study, further research could be conducted to evaluate the different responses to different areas – for example:

- Investigating knowledge transfer in non-engineering projects;
- Investigating knowledge transfer between client and project team;
- Investigating the effects of knowledge transfer, depending on the size of the project or the project team;
- Testing the model in this study on project team members in Africa or among international project teams;
- Evaluating the factors that affect knowledge transfer across the different phases in a project;
- Evaluating the effectiveness of various knowledge transfer mechanisms in transferring knowledge between senior and junior staff in engineering projects.

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