

USING PATTERNS TO CAPTURE AND TRANSFER TACIT KNOWLEDGE IN VIRTUAL PROJECT TEAMS

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ABSTRACT

As companies are globalizing, projects involving people from multiple locations are more common. Personal interaction between team members in such virtual project teams is limited in several ways. One of the functions of personal interaction in projects is the transfer of knowledge. While explicit knowledge can be shared in written form, tacit knowledge is usually shared through personal interaction. The limited personal interaction in virtual teams, therefore, provides constraints for the exchange of tacit knowledge. The pattern method is a way of capturing and encoding tacit knowledge in a structured written form. This chapter reports a study that tested the applicability of the pattern method for the capturing and transferring of tacit knowledge in virtual project teams. In a quasi-experiment, the study evaluated how this method compares to unstructured email communication for the purpose of tacit knowledge transfer. The participants generally preferred reading patterns over unstructured text and preferred the pattern method in situations that were more formalized and structured.

Keywords: Virtual teams, Project teams, Knowledge transfer, Tacit knowledge, Pattern method.

INTRODUCTION

As companies are becoming more global and many aspects of work more connected, projects involving people from multiple geographic locations will be more common (Mowshowitz, 1997b, pp. 35,48). For companies, this means that, for any project, they can form virtual teams with the people that have the most relevant knowledge and experience, regardless of their physical location (Griffith & Neale, 2001; Dubé & Paré, 2001). However, personal interaction between team members in such projects is logically limited in several ways. Meetings in person incur travel costs in terms of time and money and are therefore often of limited frequency. Technology-assisted communication through audio, video or text-based channels each have their own constraints and are no perfect substitutes for personal interaction (Isaacs & Tang, 1994; Chapanis et al., 1972).

One of the functions of personal interaction in projects is the transfer of knowledge. Polanyi (1967) introduced the distinction of two main types of knowledge: explicit and tacit, often considered to be the ends of a continuous scale (Griffith et al., 2003). While explicit knowledge is usually shared in written form, tacit knowledge is usually shared through personal interaction. The limited personal interaction in virtual teams, therefore, provides serious constraints for the exchange of tacit knowledge, which calls for more deliberate management of (tacit) knowledge in virtual teams. Several studies show that knowledge management plays a vital role in the effectiveness of virtual teams (Liebeskind, 1996; Kogut & Zander, 1992) and that its impact increases with the degree of virtualization of a project team (Griffith et al., 2003).

Management of tacit knowledge implies the systematic capturing, storing and transferring of this knowledge. However, as tacit knowledge can generally not be converted into explicit knowledge without a significant loss (Tsoukas, 2005), this bears some challenges. Lyons (2000) introduced the pattern method for capturing and transferring tacit knowledge. The pattern method is a way of capturing and encoding tacit knowledge in a structured written form, for the purpose of subsequent re-creation by another person. This chapter reports a study that tested the applicability of this pattern method for the capturing and transferring of tacit knowledge in virtual project teams. The study proposed that the pattern method is suitable for the use in virtual teams, and aimed to answer the question *How should the pattern method be applied in order to effectively capture and transfer tacit knowledge in virtual project teams?*

In order to answer this question, this chapter is structured as follows. After the introduction, the following paragraph will discuss the concepts of virtual project teams and tacit knowledge. In the paragraph following this one, describes the research strategy and design we used to study the applicability and effectiveness of the pattern method for capturing and transferring tacit knowledge in virtual project teams. The results of the study will be reported and discussed in the fourth paragraph, after which the chapter is concluded in the final paragraph in which also the limitations of the study will be addressed and some suggestions for further research will be made..

LITERATURE

This paragraph describes the main concepts that are relevant to the study. The first section covers virtual project teams by describing when and how they are formed, why they are relevant and how they differ from regular project teams. The following introduces the concept of tacit knowledge and contrasts it with explicit knowledge. This section outlines why tacit knowledge is crucial for organizations and outlines potential issues in combinations with virtual project teams. The paragraph is concluded with a description of the pattern method for knowledge transfer, and its applicability in the described environments.

Virtual Project Teams

Creation

With ongoing economic globalization, organizations themselves are becoming more global (Mowshowitz, 1997b, pp. 35,48). Besides a presence in new geographical markets, expanding companies also expand their workforce by hiring local employees and, thus, making their workforce more diverse (Dubé & Paré, 2001). Each joining employee adds their previously gained knowledge and experience to their company's global knowledge (Herzog, 2001). When faced with complex and challenging projects where rare expert knowledge is required, a company can access its global workforce and involve the people with the best matching skill profile (Griffith & Neale, 2001; Griffith et al., 2003). If relocating these employees for the duration of the project is not feasible, or if they are involved in multiple projects simultaneously, the project work will need to be conducted through communication and collaboration facilitated by technology (Boutellier et al., 1998). Such teams will be able to access their enhanced network of knowledge and expertise due to their increased diversity (Griffith & Neale, 2001; Martins et al., 2004).

Project teams that consist of a large proportion of such distributed team members are usually referred to use virtual project teams or sometimes as global virtual project teams (GVPT) (Cohen & Bailey, 1997). There is no commonly agreed-upon definition for the term. Most attempts of definitions are based on the definitions of project teams, and add constraints for virtualness, each with a different focus (Martins et al., 2004). Some of these commonly used additional characteristics are:

- use technology-supported communication substantially more than face-to-face communication (Maznevski & Chudoba, 2000);
- work and live in different countries (Maznevski & Chudoba, 2000);
- interact through interdependent tasks guided by common purpose (Lipnack & Stamps, 1997);
- work across space, time, and organizational boundaries with links strengthened by webs of communication technologies (Lipnack & Stamps, 1997);
- never meet in person (Davison & Ward, 1999; Kristof et al., 1995).

Organizations and companies operating in such a manner are commonly referred to as “*virtual organizations*” (Mowshowitz, 1997b, 1997a).

Virtual project teams are formed whenever a project uses more than one location. A study by Gartner in 2002 found that more than 60% of professional employees are working in virtual teams. This share can be assumed to have risen even further since then (Kanawattanachai & Yoo, 2002). Virtual project teams cannot just be formed explicitly and intentionally within an organization, but can also be created through outsourcing (Luczak & Hauser, 2005). When a project relies on an external supplier, especially when coordination is required, they become an extended part of the project team that will in many instances be remote and requires technology-assisted communication (Lee-Kelley & Sankey, 2008; Koskinen et al., 2003).

Challenges

The main success factor of project teams is (personal) interaction (Massey et al., 2003; Cohen & Bailey, 1997, p. 264). For virtual project teams, the possibilities of interactions are inherently limited when compared to teams located in the same room or building. Maznevski and Chudoba (2000) conducted a study by observing three global virtual teams over 21 months. During this period, a key challenge that was identified as the management of social interactions. For the teams that were dealing best with their challenges, a rhythm could be observed, structured by a beat of face-to-face meetings, with communication using other media in between. According to Joinson (2002), many members of virtual project teams were concerned that the reduced opportunities for communication and social networking would limit their career development. The case study of Lee-Kelley and Sankey (2008) outlines multiple key issues that virtual teams face. Some of these challenges were directly or indirectly related to the limited knowledge exchange in such situations. The lack of personal, ad-hoc exchange information leads to an increase need for formal training. A limited shared understanding of the project status caused dissonance within the team, as well as towards the management's agenda and decisions. Due to the more indirect ways of communication, unclear roles and responsibilities could often not be resolved, which lead to passed on tasks and subsequent delays. While the teams under consideration of the study were all virtual, it is not made clear in all instances which of the issues are caused by or especially prevalent in virtual teams when compared to co-located teams.

Tacit Knowledge

Tacit knowledge is a crucial asset to organizations (Smith, 2001). Wah (2000) argues that 99% of all work done by people is knowledge-based and that 90% of any organization's knowledge is available on people's heads (Lee Sr, 2000). This shows a high reliance on organizations on tacit knowledge, which is especially critical because it can be easily lost to an organization through layoffs, mergers and outsourcing (Bonner, 2000; Smith, 2001, 2001).

Research has repeatedly shown that in many organizations, people find it difficult to describe reasons for the way they perform their work (Cook & Yanow, 1993; Ambrosini & Bowman, 2001; Eraut, 2000). They have built up tacit knowledge of the individual steps and procedures through experience, that could be conveyed through direct interaction but is difficult to formalized (Tsoukas & Vladimirou, 2001; Nonaka, 1991; Tsoukas, 2005).

Characteristics

Knowledge is becoming the most valuable resource of companies (Kogut & Zander, 1992). It is therefore ever more vital that knowledge is managed well so that it can be preserved, shared and multiplied (Liebeskind, 1996). Polanyi (1967) has introduced the distinction between two main types of knowledge:

- Explicit knowledge can be written down, and be passed on in documents, emails, and memos.
- Tacit knowledge is implicit knowledge, that has been acquired through experience and is usually passed on through personal interaction.

Explicit knowledge (also referred to as objective knowledge) can “*be communicated from its possessor to another person in symbolic form and the recipient of the communication becomes as much “in the know” as the originator*” (Winter, 1987, p. 171). The term tacit knowledge has been introduced by Polanyi (1967) and popularized by Nonaka (1991). Polanyi (1967, p. 4) has captured the nature of tacit knowledge in the phrase “*we can know more than we can tell*”. Explicit and tacit knowledge not two distinct sets of knowledge types, but are commonly thought of as two extremes on a continuous scale (Griffith et al., 2003; Leonard & Sensiper, 1998; Ambrosini & Bowman, 2001). Based on this understanding, Polanyi (2015) and Tsoukas (2005) argue that every explicit and codified knowledge will inherently contain a tacit knowledge component as a “*personal coefficient*”. The tacit components of knowledge are often easier to remember and discuss than the explicit components (Wah, 2000; Smith, 2001; Dampney et al., 2002). Table 1 contains further aspects that are commonly associated with either tacit or explicit knowledge.

Tacit Knowledge	Explicit Knowledge	Reference
Cannot be written down without loss of information	Can be written down	Polanyi (1967)
Self-acquired via experience	Acquired from documents and through instruction	Polanyi (1967); Sternberg et al.(1995); Dampney et al. (2002)
Work practice	Work process	Smith (2001)
Know-how	Know-that, know what	Smith (2001)
Unconscious knowledge	Consciously accessible	Reber (1989), Ryan and O'Connor (2009)
Unstructured, difficult to formalize	Articulated, structured and documented	Dampney et al. (2002); Ryan and O'Connor (2009); Ambrosini and Bowman, (2001)

Table 1. Contrasting different aspects of tacit and explicit knowledge,

Transfer of Tacit Knowledge

Nonaka (1991) describes the four ways of knowledge transfer in terms of source knowledge type and resulting knowledge type. The four types are shown in table 2. Tacit knowledge can be transferred to tacit knowledge through personal interaction, or too explicit knowledge by writing it down. Explicit knowledge can be transferred to explicit knowledge by combining two or more documents into a new one. Explicit knowledge can be transferred to tacit knowledge by consuming written information.

Type of transfer	Way of transfer	
From tacit to tacit	Direct, personal exchange of tacit knowledge	Socialization
From explicit to explicit	Combining discrete pieces of explicit knowledge into a new whole	Combination
From tacit to explicit	Writing down tacit knowledge	Articulation
From explicit to tacit	Internalizing written information, to broaden one's own tacit knowledge	Internalization

Table 2. Four different ways of knowledge transfer (Nonaka, 1991).

Tsoukas (2005) argues that tacit knowledge cannot generally be converted into explicit knowledge without significant loss. However, it can be expressed through interaction, and should, therefore, be transferred directly between people. When the transfer of tacit knowledge should be facilitated, it is important to provide the necessary technical means, and sufficient space to use them (Desouza, 2003; Wickramasinghe & Lichtenstein, 2006). Foos et al. (2006) studied additional factors that have a positive influence on the transfer of tacit knowledge between two individuals. The factors which have been identified are *trust*, *early involvement*, and *due diligence*. Joia and Lemos (2010) conducted research to identify the factors that contribute to the willingness to transfer tacit knowledge. Their results yielded a number of contributors, which were classified into the three broad groups of *Idiosyncratic Traits of Professionals*, *Knowledge Management Strategy* and *Organizational Structure*. Due to the broadness of those groups, the results lack precision and are, therefore, of limited applicability for the purpose of this study.

In order to assess if a particular method of tacit knowledge transfer is successful or effective, a means of measuring the transfer is required. However, the acquisition and transfer of tacit knowledge is inherently difficult to assess, as it is often the result of implicit learning and, therefore, not part of a conscious effort (Reber, 1989). Knowledge measurement has been described as one of the most difficult activities in the area of knowledge management (Chen et al., 2009).

Sternberg et al. (2000, pp. 119-125) have described several approaches for measuring tacit knowledge. The critical incident technique (Flanagan, 1954) can be used to retrieve tacit knowledge based on past successful or particularly negative events that a person either experienced or witnessed. Behavioral event interviews can then be used to structure to articulate the respective knowledge. Another approach used simulations to artificially create situations in which a person needs to apply tacit knowledge, in combination with self-reported situational judgment tests for evaluation.

Erden et al. (2008) define the concept of Group Tacit Knowledge (GTK) and a corresponding measure of its quality (QGTK). The quality model distinguishes four different levels (in order of increasing quality).

- Group as Assemblages
- Collective Action
- Phronesis
- Collective Improvisation

So far, only the theoretical basis for the model has been defined, but so far no structured measures of it have been devised or even been empirically validated. Somech and Bogler (1999) have devised a 10-question survey to assess student's ability to acquire tacit knowledge in a university setting. While they demonstrate the successful validation of their results, an attempt by Leonard and Insch (2005) to reproduce the results was not successful. It can, therefore, be assumed that the original method by Somech and Bogler (1999) is not generally applicable. Szulanski (2000) has devised four measures of stickiness, indicators of difficulty in knowledge transfer at certain stages of the knowledge transfer process in organizations. Several predictors of stickiness are discussed and included in the proposed model with varying importance for the different stages.

Transferring Tacit Knowledge with Patterns

Many research and engineering disciplines have established practices of using pattern concepts or languages. In Lyons (2000), the pattern method for capturing and transferring tacit knowledge is introduced. The authors draw analogies to other disciplines using pattern-based tools, such as architecture and software development, where concepts are brought into pre-defined structures for storage and consumption. In the pattern method, two main concepts need to be distinguished.

- The *pattern structure* describes the pieces into which content should be deconstructed. The structure will depend on the context within the method is applied, but will often be similar to structures found in the literature.
- The *pattern instance* (or simply *pattern*) is a piece of knowledge broken down into the parts of the pattern structure.

A pattern structure could consist of the parts shown in Table 3 (Lyons, 2000) but can be adapted to specific requirements of an organization by adding, removing or changing any of the parts. To encode a piece of knowledge in a pattern instance, the previously defined structure parts are used, while ensuring that the resulting text is self-contained.

Element	Description
Pattern Name	A concise name by which the pattern can be referred to.
Problem	A concrete problem that needs to be solved.
Context	Description of the situation and involved characters.
Forces	Interests of key characters.
Solution	A solution to the problem.
Rationale	A statement on why the solution works and the reasoning behind it.
Resulting Context	The situation and context created by applying the solution.

Table 3. Common parts of a pattern structure (Lyons, 2000).

Each pattern instance should have a short, distinctive name by which it can be referred to. This allows for efficient communication about a pattern. Following the name, the situation that the pattern addresses is described in three parts. The problem describes the concrete issue that the pattern attempts to solve. This problem is set within a context, which describes the situation where this problem occurs. The involved people and their interests are described as the acting forces that contribute to the problem. These can be conflicting interests of stakeholders or other differences in opinion.

After describing the existing situation, the solution and resulting situation are described again in three parts. The solution contains an approach to solving the problem, commonly as a list of steps to follow. The following part describes the reason why these steps can be successfully used to address the problem. Eventually, the last part describes the situation and context that results from applying the solution.

Patterns provide additional context, which is essential to the creation of knowledge in the internalization process (Horvath, 2000). According to Lyons (2000, p. 132), "*Business documents are notoriously poor at capturing context, assumptions, alternatives, and other key components of any decision making process*". The structure of patterns, however, ensures that enough context is provided so that the consumer is able to gain knowledge without previous knowledge of the author's circumstances (Lyons, 2000, p. 133).

The creation of a pattern externalizes tacit knowledge. The pattern can be transferred, stored, archived or indexed for searching purposes. Subsequently, it can also be used by a reader to create tacit knowledge through internalization. The pattern structure facilitates this process. If patterns are stored in a system that facilitates searching, the clear structure allows for efficient searching of applicable patterns. In the example structure shown in Table 3, a pattern applicable in a certain situation can be found by searching for a similar Problem in a given Context.

The pattern method has already been used in practice for the development and implementation of several knowledge management systems (Kankanhalli, Tan, & Wei, 2007; Reji, 2014; Chang et al., 2008) and training strategies (Pauleen & Corbitt, 2003). Schümmer and Haake (2009) have used proto-patterns for best-practice sharing, and have found positive effects on group communication and collaboration.

Tacit Knowledge in Virtual Project Teams

As discussed above, tacit knowledge is best exchanged through personal interaction. However, the nature of virtual project teams places severe restrictions on such communication. It is, therefore, crucial to manage and facilitate the exchange of tacit knowledge in such a situation (Smith, 2001).

Knowledge Management in Virtual Project Teams

Previous research has shown that knowledge management plays a vital role in the effectiveness of virtual teams (Liebeskind, 1996; Kogut & Zander, 1992) and that its impact increases with the degree of virtualness of a project team (Griffith et al., 2003). Information and communication technologies are commonly used to enable these exchanges (McGrath & Berdahl, 2002) and can provide information and insight that is not available for co-located teams (Zuboff, 1988, p. 10).

However, Griffith et al. (2003) argue that the use of technology may destabilize the relationship between organizations and their employees when it comes to the transfer of knowledge. They suggest several organizational actions to counter such developments.

Griffith et al. (2003) built a model of knowledge transfer in virtual teams, based on which they define 13 propositions. Four of those propositions that are especially relevant to this research are shown and discussed in the following.

Proposition 1a: More virtual teams are more likely to transform implicit knowledge into explicit knowledge than are less virtual teams. (Griffith et al., 2003)

The reduced level of personal interaction is correlated with an increased level of knowledge transfer through articulation and internalization. It can, therefore, be deduced that virtual project teams have an increased demand for methods that support this kind of knowledge transfer.

Proposition 3b: Individual members of more virtual teams are less likely to acquire tacit knowledge from their teammates than are members of less virtual teams. (Griffith et al., 2003)

As argued above, tacit knowledge is a crucial factor in the quality of work. If the acquisition of tacit knowledge is limited due to the virtualness of a team, it can be argued that teams should take action to compensate for this fact.

Proposition 4a: More virtual teams will have greater difficulty forming collective knowledge than will less virtual teams. This effect will be moderated by their experienced richness of communication. (Griffith et al., 2003)

This proposition stipulates that increased richness of communication can contribute to an improved collective knowledge in a virtual team. In cases where this factor cannot be sufficiently effected, an alternative approach could be to compensate for this effect by establishing a knowledge database that team members can consult.

Proposition 9b: Tacit knowledge from members' links to communities of practice are less likely to be disseminated within more virtual teams than they are within less virtual teams. (Griffith et al., 2003)

As dissemination of tacit knowledge leads to increased overall knowledge, it can be argued that team members in such situations should be encouraged to share and transfer their tacit knowledge. It can be argued that the introduction of corresponding methods and means of communication can be used to counter this effect.

All four propositions stipulate that the virtualness of teams has a detrimental effect on their ability to exchange tacit knowledge. The propositions further suggest that the knowledge processing of virtual teams will adapt to their situation, resulting in more focus on the exchange of explicit knowledge, and in a reduction of the team's ability to utilize tacit knowledge (Griffith et al., 2003). It can be argued that virtual project teams should aim to introduce and implement methods that facilitate the exchange of tacit knowledge to compensate for those effects.

RESEARCH STRATEGY

Hypotheses

As the previous section demonstrated, the exchange of tacit knowledge in virtual project teams has several constraints. This paragraph presents the research strategy we used in order to answer the question *How should the pattern method be applied in order to effectively capture and transfer tacit knowledge in virtual project teams?*

The research question is approached by stipulating two hypotheses. The research question implies that with the pattern method it is possible to transfer tacit knowledge. The first hypothesis covers this requirement, without making any judgment about quality or comparison with other methods.

Hypothesis 1 The pattern method can be used to transfer tacit knowledge in virtual project teams.

The research question goes further than just the mere possibility of transferring tacit knowledge, and further implies that there are situations in which the use of patterns can be recommended, for example, for being superior to other methods. To validate this claim the second hypothesis states that the pattern method is more effective than the use of unstructured communication, which is often found in lessons-learned databases.

Hypothesis 2 There are situations in which the transfer of tacit knowledge in virtual project teams using the pattern method is more effective than using unstructured documents.

Research Method and Design

Empirical research on the transfer of tacit knowledge is inherently challenging because the effectiveness of transfer is difficult to measure (Chen et al., 2009). Each assessment or comparison contains a large subjective component, which needs to be considered in conducting a study, especially when comparing results between different participants. Additionally, knowledge transfer needs to be experienced in order to make any meaningful assessments. As tacit knowledge cannot be fully made explicit without loss, it is also difficult to test for tacit knowledge in the form of tests or questionnaires. Obviously, knowledge transfer also cannot be reversed, which adds an additional challenge in designing repeatable research procedures. For those reasons, the study applied the method of a quasi-experiment (Shadish et al. 2002). This quasi-experiment deviates from a full experiment by the fact that there is no random assignment to treatment and control groups. Rather each participant initially takes part as a member of the (virtual) control group, and only later as part of the (virtual) treatment group. For brevity, the word experiment is used interchangeably with a quasi-experiment in the remainder of this chapter. To mitigate effects of not having separate control and treatment groups, participants were only informed about the researched method after completing their tasks in the control group. In the quasi-experiment of our study, participants were asked to transfer tacit knowledge

to the other participants. In each instance of the experiment, the group of participants consisted of multiple members and the project manager of a virtual project team. It was not a requirement for the whole team to participate, but all participants need to be present for the experiment.

Due to the inherent difficulty of measuring knowledge transfer, the study relied on the self-reported perception of the participants to address both hypotheses. The tacit knowledge to be transferred was provided by the participants themselves. By building on the critical incident technique, they were randomly assigned two project-related situations and asked to recall solutions to these situations based on their experience with working on projects. These situations were generic descriptions of problems that can occur during projects. The following situations are given to project managers and team members in order to recall tacit knowledge.

- A project where a customer (or superior) wanted to continuously extend the scope without adapting other parameters (such as resources, time, etc).
- A project where a customer (or superior) did not accept a deliverable which met all previously defined acceptance criteria.
- A project where a customer (or project sponsor) is not willing or able to provide us client information or details for carrying out the project.
- A team member who is lacking crucial skills for contributing to the main aspects of the project.
- A project where key stakeholders are not available for communication or do not provide input or feedback as requested.
- A project where a key team member is leaving the team with one month's notice.
- A project where a key team member is leaving the team without notice. A project where it turns out after half of the initially estimated time, that the estimate was not correct and more time is required.
- A project to which you are joining midway. A project, on which you have been working since its beginning, to which one or more colleagues are joining midway.
- A project that is terminated by the customer (or project sponsor) mid-way.
- A project where do you not agree with the chosen approach or schedule.
- A project where another team member did not agree with the chosen approach or schedule.

In the first part of the experiment, the control part was conducted by asking each participant to describe the solution to a colleague in a similar situation in written form. The participants were instructed to write as they would normally do in their daily project work. To simulate the communication in virtual project teams, the texts were exchanged via email, and the participants were discouraged from verbally discussing the contents of their emails with each other. The emails were converted to plain text files by removing email headers and custom signatures, keeping only the message body. Each participant's solution was then provided to all other participants to read.

After reading all received texts, each participant assessed, for him/herself individually, how confident he/she felt to apply the described solution. This assessment was based on the following three statements that the participants were asked to rate on a Likert scale (Likert, 1932).

- *The description of the solution and its applicability was clear.*

- *The text provided enough information so that I could apply the solution myself.*
- *I feel confident that I could apply the solution described in the text myself.*

The first statement was chosen to assess the structure that the writer has used. The second statement evaluated the content of the produced text. Both of these factors are necessary requirements for knowledge transfer (Yih-Tong Sun & Scott, 2005). Finally, the third statement addressed the perceived general quality of the knowledge that was transferred. The three statements cover different aspects of the same construct of knowledge transfer. For a group of n participants, this will generate $n(n-1)$ control instances.

In the second part of the experiment, the participants were introduced to the method of patterns and were asked to repeat the same procedure with the second situation that was allocated to them. This generated the same number of treatment instances as there are control instances.

After both parts were completed, the participants were asked to complete a questionnaire to compare the methods. The survey used a Likert scale on which the participants could rate either the unstructured texts or the pattern method as more favorable in certain situations.

In this survey, the participants were first asked to give their preferences for creating and reading texts. Following this, the participants were asked to indicate their preferences for various project management situations in which knowledge is exchanged: *Project Startup Workshop*, *Sprint Review*, *Sprint Retrospective*, *Lessons-Learned Report*, *Stakeholder Analysis*, *Project Progress*. Additionally, the participants were given the possibility to add other situations. The aim of these ratings was to determine the perceived applicability of the pattern method.

Data Collection and Analysis

As described above, during the experiment data was collected from the participants with three different short surveys.

- Validation questions after the first part of the experiment, once for each unstructured text of the other participants.
- Validation questions after the second part of the experiment, once for each text using the pattern method of the other participants.
- Comparison questions.

The validation questions were designed to address *Hypothesis 1*, by verifying whether the reader has acquired knowledge from the texts. *Hypothesis 2* was addressed in two ways. A comparison of the two instances of the validation questions, which provided a general comparison of the two methods, and the comparison questions that were posted at the end of the procedure.

All survey results were collected on paper and transcribed into digital structured formats after the experiment. As is common with the analysis of Likert-scale questions, the resulting data were treated as ordinal (Clason & Dormody, 1994). For the validation questions, the possible answers were encoded from *strong agreement* as +2 to *strong disagreement* as -2. For the comparison questions, a preference for the pattern texts was encoded as +2 and for unstructured texts as -2. The numerical encoding was used to allow for simple ordering of the responses but was

otherwise not used in the analysis. Therefore no averages, deviations or other arithmetic calculations involving the distances between options were calculated (Sullivan & Artino Jr, 2013). All data analysis was carried out in R (R Development Core Team, 2008), using the psych (Revelle, 2017) and Irr (Gamer et al., 2012) libraries. The Figures in the Results paragraph were created using the Likert library (Bryer & Speerschneider, 2016).

Hypothesis testing

Hypothesis 1 The pattern method can be used to transfer tacit knowledge in virtual project teams.

The null hypothesis of *Hypothesis 1*, $H_{1,0}$ can be formulated as *No tacit knowledge can be transferred using the pattern method in virtual project teams.*

Before analyzing the data to address the hypotheses, the internal consistency of the data was verified using Cronbach's alpha (Cronbach, 1951) and Krippendorff's alpha (Krippendorff, 2007), which are both applicable to ordinal values, such as Likert scales (Hayes & Krippendorff, 2007). To falsify $H_{1,0}$, it needed to be shown that tacit knowledge can be transferred using the pattern method in virtual project teams. This argument can be based on the base assumption that tacit knowledge can be transferred in virtual teams using unstructured text.

Subsequently, the Kendall rank correlation test (Clason & Dormody, 1994) and the Wilcoxon signed-rank test (De Winter & Dodou, 2010) were used to testing if there are significant differences between the pattern and unstructured texts. If this difference could be rejected, it would be deduced that knowledge transfer is possible, which would falsify $H_{1,0}$.

Hypothesis 2 There are situations in which the transfer of tacit knowledge in virtual project teams using the pattern method is more effective than using unstructured documents.

The null hypothesis of *Hypothesis 2*, $H_{2,0}$ can be formulated as *There are no situations in which the transfer of tacit knowledge in virtual project teams using the pattern method is more effective than using unstructured documents.* To falsify $H_{2,0}$, at least one situation needed to be found in which the pattern method was perceived as more effective than the use of unstructured documents. This hypothesis was approached from two perspectives, which both were covered in the comparison questions. Firstly, the participants were prompted to assess which type of text they found easier to create and to read respectively. Secondly, they were asked to indicate their preferences for various project management situations in which knowledge is exchanged. These two questions corresponded to the processes of articulation and internalization, as discussed in the literature paragraph.

A preference for the pattern method in, at least, one of the two activities, would indicate that it would be more effective in those situations. As the activities are very generic, it would not be possible to directly derive any recommendations for its usage. The validation survey also included questions about project management situations in which the participants would prefer one method over the other. The answers to these questions were analyzed based on response counts and the corresponding medians.

The survey also contained the possibility for participants to add other situations if they considered either of the two methods applied to them. These additions were considered in the

analysis in the same way as the predefined situations but were excluded from the analysis when they were mentioned only once.

Experiment execution

In the study, the experiment was carried out two times, with six and four participants respectively. The experiments yielded a total of 94 data points from surveys, based on 20 created texts. All texts and surveys were sufficiently completed and could be used for the analysis. The situations section of the comparison question contained two omitted and one ambiguous answer. These answers have been excluded from the analysis while including the remaining answers to the respective questionnaires.

The participants have been chosen by contacting Project Management Offices or similar entities from multiple companies in Europe. Potential participants were required to have experience with working in virtual project teams but did not necessarily have to be members of the same project. For practical reasons groups of at least four people were required, and each applicant needed to have access to an email account for the time of the experiment. Based on the received responses and the availability of the potential participants, all participants were recruited from one Austrian IT services company. Two groups were formed and the experiment was carried out with each of the groups individually. Within each group, the members had at least some shared work experience. To avoid any bias during the control iteration, the participants only received information about the modalities and procedures, but not about the contents before the experiment. However, due to the selection process, an inherent selection bias cannot be ruled out.

RESULTS

This paragraph describes the analysis that has been conducted using the data from the performed experiments.

Knowledge transfer

This section tries to verify *Hypothesis 1* and was based on the answers to the validation questions with a sample size of $n=84$. The samples were split evenly between control and treatment responses for unstructured texts and patterns, respectively. Cronbach's alpha of the validation questions was 0.86, which is a good measure of internal consistency and showed that the participants understood the questions (Joia & Lemos, 2010). Krippendorff's alpha for the answers to the validation questions was 0.552, which is a moderate measure of internal agreement (Hayes & Krippendorff, 2007). Based on these two measures, the data could be considered sufficiently reliable for further analysis.

Figure 1 shows a plot of the responses to the three questions, grouped by whether they were made for unstructured texts or patterns.

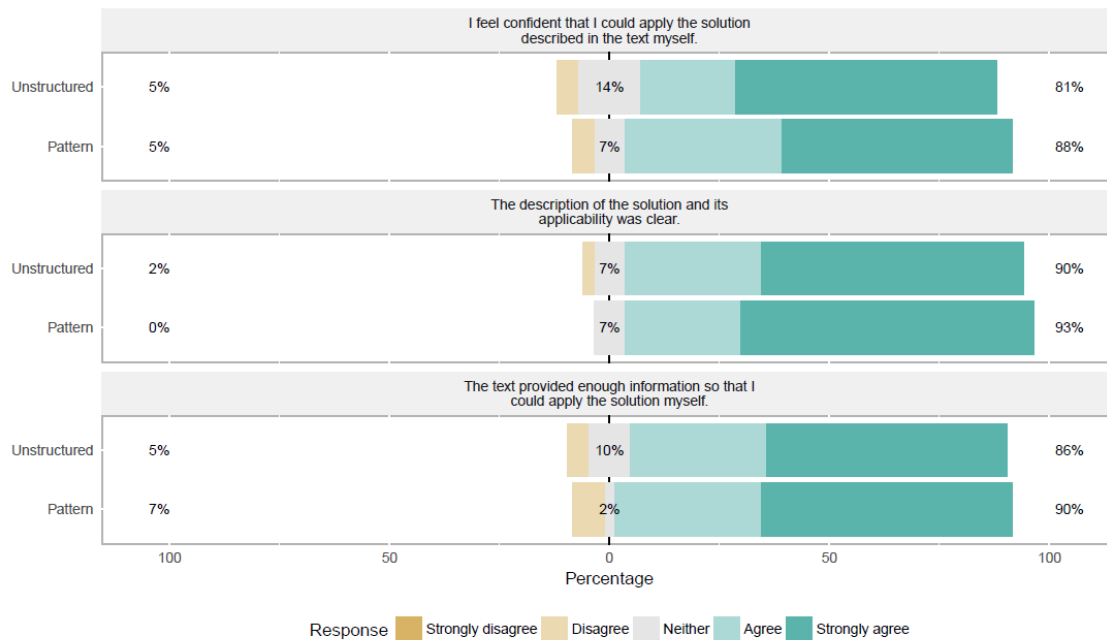


Figure 1. Validation

$H_{1,0}$ could be falsified by showing that there was no significant difference between the responses for the unstructured texts and the uses of patterns. This was verified calculating Kendall's tau, as a measure of rank correlation. As can be seen from Table 4, as well as from Figure 1, there was a high level of correlation for the answers to each of the three questions (in Table 4 referred to as *Description*, *Information*, and *Confident*). A Wilcoxon signed-rank test was used to confirm the statistical significance of the similarity of the responses.

Question	Kendall's tau	Wilcoxon signed-rank test, p
Description	0.8701166	1.284e-10
Information	0.9353771	1.947e-7
Confident	0.8660782	1.291e-7

Table 4. Correlation

The medians of all six response segments were between the options *Agree* and *Strongly Agree*. The results showed that while the transfer of tacit knowledge is possible, it does not give a significant improvement over the use of unstructured texts.

Applicability

To answer our research question, *Hypothesis 2* suggested that there are situations where the pattern method is more effective than the use of unstructured texts and should be preferred. The research design covered two aspects of *Hypothesis 2*, both covered by the validation questions. They were answered once by each participant, resulting in a sample size of $n=10$.

For the first aspect of the hypothesis, the comparison questions considered the process of creating and reading both types of texts and assessed which has been easier respectively. Figure 2 shows a plot of the responses.

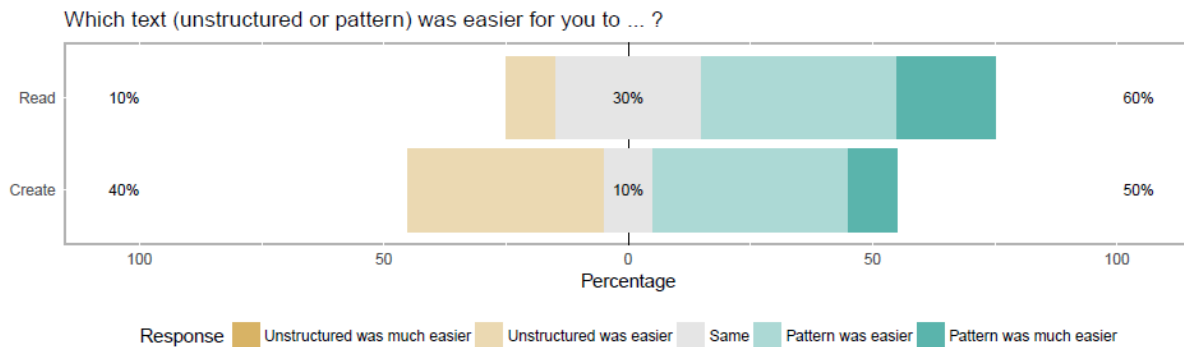


Figure 2. Create / Read Preferences

For creating texts, the participants showed a mostly balanced response with a median between the options *Same* and *Pattern was easier*. For the reading of texts, participants showed a preference for the pattern method with the median at *Pattern was easier*. A Wilcoxon signed-rank test was used to test whether the two sets of responses have a statistically significant similarity. The resulting p-value of 0.3008 does not support such a similarity, based on which the null-hypothesis $H_{2,0}$ can be rejected.

To assess in which situations the pattern method can be applied, the participants were asked to choose their preferred method for a set of predefined project management situations. As can be seen from Figure 3, the participants strongly preferred the pattern method for *Stakeholder Analysis*, *Project Progress Report*, and *Lessons-Learned Report*. For those situations, there were no responses that indicated a preference for unstructured text. The median for these options was *Prefer patterns*.

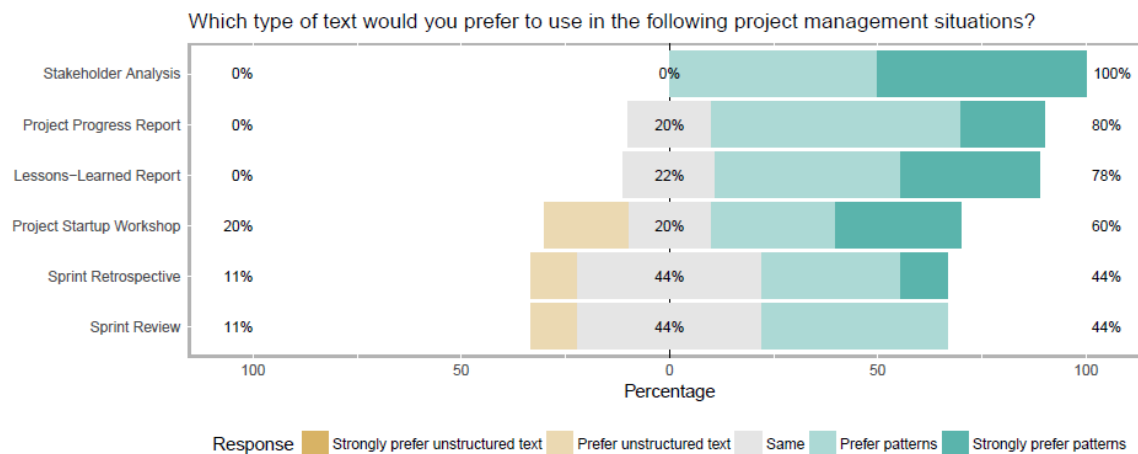


Figure 3. Situation Preferences

For *Project Startup Workshop*, *Sprint Retrospective* and *Sprint Review* some participants preferred unstructured text. However, these were also outnumbered by other participants preferring the pattern method.

The participants also added the situations *Incident Report*, *Crisis Meeting*, and *Brainstorming*. However, each of them was mentioned only once, so they were not considered in the analysis.

Discussion

The previous section described the analytical methods that were applied to the responses to the questionnaires to test the hypotheses. The data proved to be consistent, indicating that the design of the survey was sound and that the responses can be used as a reliable basis for the subsequent analysis.

To address the first hypothesis, *The pattern method can be used to transfer tacit knowledge in virtual project teams*, three ratings for perceived quality of knowledge transfer were collected for both methods. All of the statements have been rated very positively regardless of the method used. The performed tests confirmed that there was no significant difference between the methods. While this confirms that knowledge transfer using patterns is possible, it can also be interpreted from this result that in general, the pattern method does not give any significant improvements in terms of the perceived quality of transfer of tacit knowledge, when compared to the use of unstructured text.

This comparison of the two methods was addressed in the second hypothesis, *There are situations in which the transfer of tacit knowledge in virtual project teams using the pattern method is more effective than using unstructured documents*. Our analysis showed that participants prefer the usage of the pattern method for reading. Responses for writing showed no clear preference for either of the two methods. Further, the data showed a clear preference for the pattern method in three project management situations: *Stakeholder Analysis*, *Project Progress Report*, and *Lessons-Learned Report*. For the other surveyed situations, *Project Startup Workshop*, *Sprint Retrospective*, and *Sprint Review*.

It may be observed that the situations where the use of patterns was preferred are more formalized and structured, whereas the situations where the preferences were more balanced are more interactive and less structured.

The earlier discussed propositions by Griffith et al. (2003), basically state that virtual teams will exchange less tacit knowledge compared to non-virtual teams and that they have to rely more on methods for articulation and internalization of such knowledge. Based on the results of our study, it can be argued that for more structured and formalized project management situations, the pattern method is a suitable tool to facilitate the exchange of tacit knowledge in virtual project teams. This corresponds with the study of Sternberg et al. (2000, pp. 108-109), which describes the use of condition-action pairings, as which patterns can be seen in this context. Our results also confirm and extend the work of Schümmer and Haake (2009), which used proto-patterns for best-practice sharing. They found a generally positive effect on group communication and collaboration but did not distinguish applicable situations.

CONCLUSION

This chapter reported a study in the applicability and effectiveness of the pattern method (Lyons, 2000) for capturing and transferring tacit knowledge in virtual project teams.

Based on the quasi-experiment research design, our study found that the pattern method provides some benefits over unstructured texts for sharing tacit knowledge in virtual project teams.

The participants of the study generally preferred reading patterns over unstructured text. From this, it can be concluded that patterns should be taken into consideration for information that is intended to be read many times, or that remains valid for a long period of time.

From the project management situations that were used in the experiment, it could be concluded that the pattern method was preferred in situations that are more formalized and structured, such as *Stakeholder Analysis*, *Project Progress Report*, and *Lessons-Learned Report*. By extracting sections, such as the context, problem descriptions and forces from the remaining content, queries can be made more specific when searching through databases of solutions. Such use cases would be especially applicable to *Stakeholder Analysis* and *Lessons-Learned Reports*, as they are intended to be valid for longer periods of time, and might be reviewed at later stages of a project, or even outside of the project that the documents were created for. From our study, it can also be concluded that the participants preferred a common and predefined structure for those documents. This is especially important in the context of virtual project teams, where this information is often only available from documents and cannot easily be discussed with colleagues in person.

In summary, the results showed that virtual project teams should consider the pattern method for documents that they plan on accessing and using for a long period of time, especially when they can be stored in a structured or semi-structured way. Such teams are advised to define pattern structures most suitable for their own purposes and implement templates as well as structures accordingly so that they can be made available to team members.

The research carried out as part of this work has several limitations, that should be acknowledged and discussed in this section. As outlined earlier, the measurement of knowledge transfer is an inherently difficult problem. Due to the lack of other feasible approaches, this study has relied on the self-reported perception of knowledge transfer, which has been partially compensated by cross-rating.

All participants of the experiments have been from the same company, and within each experiment group, there were shared project histories. Therefore some degree of group knowledge (Kogut & Zander, 1992) inevitably existed between the participants. Furthermore all participants had met in person before and during the experiment. To control for these limits on the virtualness of the project teams, the experiment could be repeated with participants without shared project history or members from fully virtual teams.

Due to the participant selection process, a selection and confirmation bias is possible. The available participant pool was not sufficient for controlling for this factor, and the sample sizes did not allow for subsequent correction. Also, as most of the experiments relied on perceived applicability of the method, performing it with participants from different cultural or professional backgrounds might yield different results.

This research used the participants' self-reported assessments for the quality of knowledge transfer as its main data source. However, other factors, such as the process duration and content structure, could also be considered in the analysis and might provide additional insights.

FUTURE RESEARCH DIRECTIONS

As outlined in the previous section, additional data would be available to be recorded during the experiment execution. The time required to create and read the texts could be used to derive the difficulty of applying a particular method. In addition, the contents of the created texts could be analyzed for length, complexity, and included information to draw further conclusions about the effectiveness of the methods. Furthermore, a larger and more diverse participant group could be used to repeat the experiments in order to verify the results with a larger sample size.

This work has focused on the comparison between the pattern method and the use of unstructured text. However, similar comparisons can be made also to other different methods or means of communication. This would then allow to create a more comprehensive comparison.

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