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Understanding hybrid team dynamics: Relationships among task interdependence, team communication, shared mental models, and team performance

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Abstract (English)

Despite their growing prevalence, research on hybrid teams which combine remote and in-person work remains limited. This thesis examines the relationships between task interdependence, quality of communication, shared mental models, and team performance in hybrid teams. Drawing on team communication and shared mental model theories while supported by the input-process-output (I-P-O) framework, this study aims to deepen understanding of hybrid team dynamics. Data were collected from 536 students in 127 teams across six university classes, who completed a collaborative task under hybrid conditions. The final sample size included 113 teams. Key constructs were measured using validated scales, and hypotheses were tested through partial least squares structural equation modeling. Results show significant positive associations between both quality of communication and shared mental models with team performance, as well as between quality of communication and shared mental models. However, no relationship could be examined between task interdependence and either quality of communication or shared mental models. Limitations include possible common method bias from self-reports, the lack of longitudinal data inhibiting causal inferences, and the student sample reducing generalizability of the results to organizational settings. This study highlights the importance of communication quality and shared mental models in enhancing hybrid team performance. Practical implications include fostering communication quality and shared mental models strategies early within hybrid teams' life cycles. Future research should expand sample size, employ longitudinal designs, and investigate hybrid teams in organizational contexts.

Keywords: hybrid teams, task interdependence, quality of communication, shared mental models, team performance

Abstract (German)

Hybride Teams kombinieren Online- und Präsenzzusammenarbeit und weisen eine zunehmende Verbreitung auf. Nichtsdestotrotz ist die Forschung zu hybriden Teams bisher limitiert. In dieser Arbeit werden die Beziehungen zwischen der Interdependenz von Aufgaben, der Qualität der Kommunikation, der geteilten mentalen Modelle und der Teamperformance in hybriden Teams untersucht. Die vorliegende Studie stützt sich auf Theorien zur Teamkommunikation und zu geteilten mentalen Modellen, die durch das Input-Prozess-Output-Modell (I-P-O) ergänzt werden, und zielt darauf ab, das Verständnis der Dynamik hybrider Teams zu vertiefen. Es wurden Daten von 536 Studierenden in 127 Teams verteilt auf sechs verschiedene Universitätsseminare erhoben, die eine Teamaufgabe unter hybriden Bedingungen durchgeführt haben. Die finale Stichprobengröße bestand aus 113 Teams. Konstrukte wurden anhand validierter Skalen gemessen und die Hypothesen durch Partial-Least-Squares-Strukturgleichungsmodellierung getestet. Die Ergebnisse zeigen signifikante positive Assoziationen zwischen der Qualität der Kommunikation und Teamperformance, zwischen geteilten mentalen Modellen und Teamperformance, sowie zwischen der Qualität der Kommunikation und geteilten mentalen Modellen. Es konnte jedoch kein Zusammenhang zwischen der Interdependenz der Aufgaben und der Qualität der Kommunikation oder geteilter mentaler Modelle getestet werden. Zu den Einschränkungen gehören mögliche Verzerrungen durch Selbstberichte, die Hemmung kausaler Schlussfolgerungen durch das Fehlen von Längsschnittdaten, und die aus Studierenden bestehende Stichprobe, die eine Generalisierung der Ergebnisse auf Organisationen einschränkt. Die Studie unterstreicht die Bedeutung der Qualität der Kommunikation und der geteilten mentalen Modelle für die Verbesserung der Performance hybrider Teams. Zu den praktischen Implikationen gehört die Förderung der Qualität der Kommunikation und der Strategien für geteilte mentale Modelle zu einem frühen Zeitpunkt in der Zusammenarbeit von hybriden Teams. Zukünftige Forschung sollte den Stichprobenumfang vergrößern, Längsschnittdesigns verwenden und hybride Teams in organisationalen Kontexten untersuchen.

Schlagwörter: Hybride Teams, Aufgabeninterdependenz, Qualität der Kommunikation, geteilte mentale Modelle, Teamperformance

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1 Introduction

Teamwork takes up 80% of the average employee's day (Cross et al., 2016). This can range from collaborating in a small team of three or four individuals to working together in large teams with multiple members. Work teams harness the collective intelligence of individuals, pooling together a wide range of skills, knowledge, and perspectives (Janssens et al., 2022). Therefore, teamwork is assumed to offer distinct benefits over individual efforts, resulting in process gains (Mojzisch & Schulz-Hardt, 2011) and enhanced performance (Schmutz et al., 2019). The concept of work teams plays a critical role in a variety of organizational settings as their members' diverse skills and perspectives enable the team to address complex problems that would be challenging for individuals to resolve on their own (Glassop, 2002; Laughlin et al., 2006). Once teams manage to communicate with high quality, this further enhances their level of performance (Mesmer-Magnus & DeChurch, 2009), providing another advantage.

While the concept of workplace teams has been existing in organizations for several decades (Mathieu et al., 2008), they are continually evolving to effectively navigate the complexities of the modern digital landscape. Already a decade ago, information communication technology (ICT) like emails, video call tools, or chat tools was seen as indispensable media within workplace teams (Maynard & Gilson, 2014). Today, any modern organization juggling the post-covid normalization of home office and flexible working hours is dependent on multiple ICT tools. Hence, at a time where cutting-edge technology has an impact on nearly all relevant topics in our society, it has also created a significant change in teamwork in modern organizations. In 2022, 50% of all enterprises within the European Union containing of 10 or more employees conducted remote meetings via ICT (Eurostat, 2023). Differences between the individual countries do exist, with 79,4% of Sweden's enterprises on the top versus 29,4% of Hungary's enterprises coming in last. Germany results in 60,5%, exceeding the EU average by 10%, while Austria scored just the average by their 49,5%. However, regardless of the national distinctions, 50% of EU enterprises with more than 10 employees have increased their number of remote meetings in 2020, of which 97% made that decision at least partly because of COVID-19 (Eurostat, 2021). Therefore, it is of little surprise that virtual and hybrid teams are seen as the new normal in numerous organizations around the globe (Garro-Abarca et al., 2020; Brown et al., 2021; Marino-Romero et al., 2022). The global pandemic has not only been a catalysator in normalizing remote meetings, but also in keeping the option for remote work after employees could return to the office (Lang et al., 2022). These teams are called hybrid teams – teams which operate both in the office setting and remotely.

The request for more flexibility and adaptability at the workplace has created a need for these teams (Iqbal et al., 2021). The combination of regular remote working days while still using the office space has been normalized during the previous years. However, while hybrid teams have by far secured their spot in the modern work environment, research is still only starting.

When researching teams, most work has focused on identifying the factors that impact outcomes such as team performance. The extent to which team members depend on each other to accomplish their tasks, i.e., task interdependence, has frequently been assessed as an input factor which in turn is expected to antecedently effect the relationship between team processes and performance (e.g., Cohen & Bailey, 1997). Furthermore, it has been directly associated with team communication (Rico & Cohen, 2005) as well as indirectly with team performance (Hertel et al., 2004). Within hybrid teams, task interdependence has not been researched yet. Furthermore, team communication has consistently been identified as an important factor of team performance (Marlow et al., 2018), both with solely face-to-face teams (e.g., Salas et al., 2005) and solely virtual teams (e.g., Shockley et al., 2021). However, the blending factor of hybrid teams with team members operating both from the office and remotely has not yet been adequately integrated. To work well together in a team, shared understanding of communication processes is crucial. Therefore, the concept of shared mental models, the overlap of individual team members' mental representations, has been identified as another crucial characteristic of a high performance level in face-to-face teams (e.g., DeChurch & Mesmer-Magnus, 2010). In virtual teams, this relationship has been addressed by a theoretical framework (Maynard & Gilson, 2014), while hybrid teams have been neglected so far.

Given the enormous demand of hybrid teams in today's modern work environment, this type of teams should be explicitly researched in more detail in order to provide knowledge about how to effectively manage such teams. Therefore, this thesis is aiming to contribute to the research gap of hybrid teams in order to take up with today's reality of teamwork. The present study is using data of student teams that have collaborated in hybrid setting, that is, co-located and remotely. Despite the clear parallels to work teams, the results can only limitedly be transferred into the organizational work environment. Nevertheless, the objective of this work is to explore team communication, shared mental models, and task interdependence as key concepts that are frequently studied in the context of traditional face-to-face teams, examining their interrelationships and their impact on team performance within the context of hybrid teams.

2 Theoretical Background

2.1 From Teamwork towards Hybrid Teams

Resembling definitions about the concept of a team describe it as a group of individuals who rely on one another to accomplish their tasks. They work towards one or more common goals and share collective responsibility for the outcomes of their efforts. Team members possess a sense of organizational identity and are recognized both internally and externally as a cohesive social unit while they have different roles and responsibilities within their team (Cohen & Bailey, 1997; Mathieu et al., 2008, Salas et al., 1992).

Teamwork in organizations has a long history, especially in the face-to-face context. Teams have become increasingly widespread across all types of organizations (Devine et al., 1999). Companies around the world are continuously transitioning from individual roles within functional structures towards teams integrated into multifaceted work cycles (Kozlowski & Ilgen, 2006). Thereby, the dynamic and complex nature of teams is often emphasized, as well as the team's capability to develop their member interaction, and to evolve based on situational demands (Arrow et al., 2000; Marks et al., 2001). Just like their existence, the research of face-to-face teams has been well established.

Teams who meet, communicate, and make decisions while their members are physically present in the office has been the normality for decades. However, due to the rise of information communication technology (ICT), the communication has been expanded towards emails, video calls, and online chat systems (Martins et al., 2004). Consequently, a great number of work teams can nowadays be referred to as virtual teams. Virtuality characterizes the extent of usage of ICT within work teams (Kirkman & Mathieu, 2005), and members of a virtual team are generally spread across different geographical locations (Dulebohn & Hoch, 2017). Initially, scientific team research has classified face-to-face teams – teams that communicate in person – and virtual teams – teams that communicate via ICT – as dichotomous. Various studies have conceptualized virtuality as a categorial variable, contrasting it with face-to-face teams. One reason for this was outlined by Martins et al. (2004) who claimed that initial research on teams has majorly taken place in laboratory settings. Since then, however, field settings in organization teams have been predominant. Therefore, the artificial dichotomy of virtual and face-to-face teams could no longer adequately depict the reality as many teams nowadays have included both face-to-face and ICT communication in their work cycle. Kirkman and Mathieu (2005) have faced this inconsistency by introducing an updated conceptualization of virtuality, focusing on the extent of a team's virtuality. According to them, team virtuality can be measured on a continuous scale which reaches from face-to-face communication only to ICT

communication only. Any work team can be placed somewhere on this scale, and the extent of virtuality – the extent to which the team communicates via ICT – can be measured.

It is hardly surprising that most of today's work teams hold an intermediate position on this continuum, neither only communicating in person nor only communicating through ICT (Hosseini, 2017). The rapid increase of technical tools has quickly found its way into organizations and their work settings (Richter & Richter, 2024). Furthermore, the COVID-19 pandemic has caused a massive increase in home office activities (Lang et al., 2022) which has lasted to this day. Not only teams which are geographically dispersed by their members being based in different cities or even countries, but also teams in which their members all, or to a great extent, live in the same city, have adopted ICT in order to pursue their everyday communication. Emails, video conferences, and chat have been installed as daily tools of finishing tasks. Meanwhile, team members who share an office or who coincidentally are present at the office on the same day are still relying on face-to-face communication (Tang & Bradshaw, 2020).

Hybrid teams are work teams in organizations which combine physical work at the office and a remote working setup (Cook et al., 2020). In essence, some team members are physically present at the office while others work from home or elsewhere than the office. Often, the same people make use of both working arrangements, working from the office on some days, and remotely on other days (Iqbal et al., 2021). Therefore, a hybrid work model combines on-site and remote work while enabling employees to alternate between physically attending their workplace and working virtually from any location. This approach allows organizations reliant on traditional office operations to benefit from the advantages of remote work – such as increased flexibility, reduced costs, and improved employee satisfaction – while still leveraging the benefits of in-person collaboration and hands-on engagement (Iqbal et al., 2021).

Hybrid teams have entered the modern workplace and rapidly increased in prominence. Even after the obligatory work from home during the highs of the COVID-19 pandemic, many organizations have kept home office possibilities. This has also been welcomed by employees, the majority of whom stated they do not want to return to full time office work after the pandemic (Šmite et al., 2023a). As of today, the possibility to work remotely for at least a part of the working hours has become a benchmark in most modern organizations (Gratton, 2022). By revisiting and refining their traditional workplace policies, many organizations have created the flexibility to address the challenges of a hybrid work model.

The advantages of hybrid teams resemble those of virtual teams: geographical and temporal limits are diminished or even eliminated (Alves et al., 2023), experts from anywhere

can join a meeting, increasing the team expertise (Dulebohn & Hoch, 2017), and quite often a better work-life balance is perceived (Šmite et al., 2023b). Additionally, members of many hybrid teams still have the possibility to meet in person if the need is there. They still have the possibility to show up at their office in person, to meet with colleagues, discuss things in person and share a lunch break. These aspects of face-to-face teams are what workers highly value, no matter how advanced their teams' ICT has become. Some employees in every company desired to return to the office on a regular basis when being asked during a fully remote work cycle in 2020 (Šmite et al., 2023a). This combination of the advantages of face-to-face teams and those of virtual teams is what makes hybrid teams so popular. Furthermore, a keyword of success is flexibility. Flexible working hours as well as alternating on-site office and off-site home office is what matters to many modern employees (Iqbal et al., 2021). Additionally, work from home can improve the quality of both physical and mental health, for example by creating the possibility to sleep longer, to cook proper meals, or to be less frequently interrupted during working hours (Tavares, 2017). Moreover, it has positive effects on job satisfaction (Niebuhr et al., 2022). However, next to these clear benefits, downsides such as depression and isolation through lack of social contact are equally important to mention (Tavares, 2017). Furthermore, flexibility diminishes predictability which in turn complicates team collaboration and increases the need for high communication quality (Iqbal et al., 2021). Some employees may primarily experience the positive sides while others mainly experience the negative ones. The different aspects of hybrid work have different impacts on different personalities and teams. However, the flexibility of hybrid work is often seen as a representation of the best of both worlds (Iqbal et al., 2021).

2.2 Theoretical Models in Team Research

When conceptualizing work teams, focus often lies within the dynamics and evolving nature (Kozlowski & Ilgen, 2006). They develop over time and team characteristics are often described as processes rather than static units. Team research is subject of numerous amounts of research papers. The vast majority tries to identify the relevant factors which have a crucial role in reaching high values of team effectiveness and successful team performance. Thereby, the input-process-output (I-P-O) theoretical model approach has been established and is still representing the prevailing technique of modeling influences on team effectiveness (Badke-Schaub et al., 2007). The I-P-O model's fundamental idea is the influence of input factors on team processes, which in turn influence output factors. It was first introduced by McGrath (1964) and has been picked up and developed since, for example by Salas et al. (1992), and Hackman (1983). However, they all rely on the initial approach. Input factors often represent

factors on an organizational, team, and individual level such as organizational culture, team interdependence, or individual expertise of team members. Team processes, which are influenced by input factors, are mostly represented by team communication and team coordination. Output factors, which are in turn influenced by team processes, are often measures of team effectiveness or team performance. Furthermore, output factors are sometimes divided into mere quality of performance and satisfaction of team members. Cohen and Bailey (1997) have added another component, group psychological traits, which relates with the team process. An example of a psychological trait is shared mental models which can be defined as the overlap of individual team members' mental representations concerning both the team and the task. By adding this component, the dynamic nature of team processes has been highlighted. Marks et al. (2001) agreed with this view while further arguing that the way relationships of team factors are displayed in a mere I-P-O model is too static and unidirectional. In the course of this, they suggested to rename group psychological traits into emergent states while highlighting the importance of including cognitive, motivational and affective states in the I-P-O baseline model. Furthermore, they emphasized the bidirectional relationship between emergent states and team processes. The example of communication and shared mental models illustrates this approach: While it is crucial to communicate in order to inform each other about individual cognitive representations at the beginning of a team's life cycle, congruent shared mental models can foster a huge increase in communication quality once they have been established (Badke-Schaub et al., 2007). Both team communication and shared mental models can therefore be seen as influential to team effectiveness. Marks et al. (2001) have further emphasized the importance of feedback loops, particularly owing to the advancement of teamwork while tackling a task. Teamwork is represented by a dynamic and cyclic character, especially in organizational teams which are the focus of modern research rather than artificial laboratory settings (Martins et al., 2004). The previous example of the relationship between team communication and shared mental models already highlights the dynamic character. Badke-Schaub et al. (2007) further emphasize this dynamic nature of teams by describing team processes as feedback circles. Connections between influential factors of team effectiveness are multidimensional and cannot be viewed in a unidirectional way. Therefore, a theoretical model which isolates input factors, team processes, and output factors, and plants them onto a purely unidirectional approach cannot be seen as fully representative for modern teamwork settings and hence should not be taken as granted when interpreting results (Kozlowski & Ilgen, 2006). Relationships between possible influences of team effectiveness should rather be interpreted with caution and not be viewed in an isolated way. A single research paper on teamwork is not

able to cover all influential factors, which seems quite logical due to the complexity of team research. Nevertheless, the possibility of influences of other factors should always be in the back of the head.

This thesis is diving into the rather new research field of hybrid teams where similar challenges arise. Here, the concepts task interdependence, team communication, and shared mental models are being examined. It is important to note that these concepts are only a part of all relevant aspects which can have an influence on team dynamics. However, they should be considered as crucial and be included in further research. Hence, the team effectiveness model by Cohen and Bailey (1997) functions as a supportive structure while acknowledging the dynamic nature of team processes and effectiveness. The model represents a heuristic framework which considers merely unidirectional relationships in teams as outdated. Instead, it includes interactions, for example the interaction of shared mental models and team communication. The team effectiveness model by Cohen and Bailey (1997) emphasizes team effectiveness as a result of task design factors, environmental factors, group processes, and group psychological traits. In this case, task interdependence represents a task design factor, team communication falls under the category of group processes, and shared mental models functions as a group psychological trait. According to Cohen and Bailey (1997), team effectiveness can be subdivided into performance outcomes (e.g., quality, productivity), attitudinal outcomes (e.g., job satisfaction, trust), and behavioral outcomes (e.g., turnover absenteeism). In the following examinations, focus will be placed on team performance. It would go beyond the scope of this thesis to further include job satisfaction and team trust which certainly equally exhibit the need to be researched in the context of hybrid teams. However, in this work, theoretical derivations have focused on team performance as the main outcome factor, which is why focus will lie on this concept.

With the heuristic framework of team effectiveness by Cohen and Bailey (1997) being of importance for the upcoming hypotheses, it is crucial to note that due to the data structure, any possible causal derivations have to be taken with great caution and should rather be viewed as mere relationship between two concepts. Furthermore, it is important to note that a theoretical model of teamwork functions as a supportive baseline for the research question and hypotheses, but not all its components are included.

2.3 Team Performance

Over the decades, the view of team performance has substantially changed. While work performance has traditionally been assessed thinking about mere proficiency, this view has been challenged, resulting from the evolving nature of work and organizations (Griffin et al., 2007).

Earlier, team performance as an outcome of team process was understood as successfully completed once the professional requirements for the job was fulfilled (Murphy & Jackson, 1999). Today, it is much more dynamic. In their model of work role performance, Griffin et al. (2007) underline the importance of the full set of work roles which contributes to a team's effectiveness. They have identified three levels at which role behaviors can enhance effectiveness – the individual, team, and organizational level. For this study, the team level is particularly relevant. Furthermore, three types of behavior – proficiency, adaptivity, and proactivity – can be classified as subdimensions of performance. This results in nine subdimensions of work role performance. Individual task proficiency refers to the extent to which an individual effectively fulfills the core tasks and responsibilities of their job role as specified. It focuses on meeting known expectations in a predictable environment. Traditional approaches have treated team performance similar to this dimension. Team member proficiency means the ability of an individual to meet the expectations of their role within a team, while coordinating and collaborating effectively with team members. Organization member proficiency refers to behaviors that align with organizational goals and expectations, such as upholding the organization's image and participating in activities that benefit the organization as a whole. Entering the second type of behavior, individual task adaptivity is the capacity of an individual to adjust to changes in their tasks or work environment, demonstrating flexibility in handling new challenges. Second, team member adaptivity refers to the ability to respond constructively to changes within the team, such as adapting to new team structures or shifts in team dynamics. Finally, organization member adaptivity is the extent to which individuals can cope with and support changes at the organizational level, such as restructuring or new policies. Proactivity marks the third type of behavior. Individual task proactivity describes self-initiated, future-oriented behavior aimed at improving one's tasks or work processes to enhance performance and effectiveness. Team member proactivity refers to proactive behavior directed at improving team functioning, such as suggesting new ways to enhance teamwork or addressing team inefficiencies. Finally, organization member proactivity means the extent to which individuals engage in proactive efforts to improve organizational practices, policies, or overall effectiveness.

These nine subdimensions have been explained extensively for a reason: Throughout the present study, team performance plays a crucial role as it serves as dependent outcome variable. It is worth mentioning that the view of team performance on the team level receives the focus in the current study. Studying team performance on team level allows to focus on the collective

group rather than individual traits (Meyers et al., 2023). Furthermore, highlighting the behavioral component should emphasize the team performance approach of this thesis.

2.4 Task Interdependence

Teamwork requires interaction with other team members, with whom each individual has a certain degree of interdependence. Consequently, completing tasks within a team demands collaborative interaction and information sharing in order to be able to reach the intended results (Stewart & Barrick, 2000). Task interdependence refers to the degree to which team members rely on one another to complete their work. High interdependence appears once a task demands a high level of cooperation between team members since they are dependent on each other concerning material and information (Campion et al., 1993). Task interdependence is seen as a structural characteristic of the practical connections that exist among team members (van der Vegt et al., 2001). Johnson et al. (2014) describe interdependence as relationships among team members, which, in turn, shape the information needed for the team to carry out interdependent tasks. Task interdependence has been considered in team research for several decades while often being classified in four fundamental structures: Pooled, sequential, reciprocal, and intensive interdependence (van de Ven et al., 1976). Pooled and sequential interdependence represent lower levels of interdependence since the performance result can be reached by adding individual performances onto another (Maynard & Gilson, 2014). With reciprocal interdependence, the workflow goes back and forth which requires more interaction among team members – in this case it is time-delayed (van de Ven et al., 1976). Intensive interdependent tasks demand the highest level of collaboration among team members since it now must occur simultaneously to identify and solve problems (Saavedra et al., 1993). The level of task interdependence among team members generally rises as tasks become more complex and individuals need additional support to perform effectively. For example, in a sales department, team members often work independently, whereas roles within surgical teams demand much closer collaboration. Though, even within a single team, this level of interdependence can vary. For instance, an anesthetist in a surgical team operates more independently compared to surgeons and their assistants. This shows that variations in interdependence exist both across different groups and within the same group, depending on the specific responsibilities of each role (van der Vegt et al., 2001).

Task interdependence can be seen as task design factors which can directly be altered by decision-makers in order to provide the tools for effective performance (Cohen & Bailey, 1997). They shape both team processes and group psychological traits, and through this, leverage for outcomes. Furthermore, due to the cyclic character of a team, reciprocal influence is possible,

depending on where the team currently stands. Wageman (1995) found interdependent tasks to facilitate internal team processes. Additionally, tasks with high interdependence demand more effective communication than those with lower interdependence. This implies that task interdependence not only enhances the frequency of communication but also improves its quality within the team (Ashouri et al., 2024).

Furthermore, higher levels of task interdependence promote the formation of shared mental models among team members (Maynard & Gilson, 2014). As team members rely more on each other to complete tasks, they are more likely to develop a common understanding of their work. Additionally, teams with higher task interdependence tend to develop more similar task-focused shared mental models (Zhou, 2017). In conclusion, task interdependence may be of importance in shaping shared mental models by fostering collaboration and information sharing among team members. This, in turn, leads to more effective teamwork and improved performance.

However, task interdependence is not always treated as an antecedent of team process. In the meta-analysis about the relationship of team communication and performance by Marlow et al. (2018), they found task interdependence to be an amplifier of this relationship. When tasks were highly interdependent, communication provided substantial assistance to a high level of team performance. Hertel et al. (2004) found a positive effect of more interdependent tasks on the effectiveness of virtual teams. They argue that some of the difficulties which naturally come up in virtual team settings can be buffered by designing team tasks in an interdependent way. Kozlowski and Bell (2003) have proposed that task interdependence might play a crucial role in the relationship between shared mental models and virtual team performance. Furthermore, DeChurch and Mesmer-Magnus (2010) claim that high interdependence strengthens the influence of team cognition, namely shared mental models, on team performance. Additionally, interdependence shapes the team's performance strategies, which subsequently has a positive impact on overall team performance (Saavedra et al., 1993). In virtual teams, task interdependence has been found to impact the relationship between the use of ICT and team performance (Martins et al., 2004; Maynard et al., 2012).

Generally, task interdependence is considered to have a strong influence in virtual teams (Marlow et al., 2017). For example, within virtual teams, highly interdependent tasks lead to the team being faced with major challenges if synchronous communication is absent (Straus & McGrath, 1994). Effective information communication technology preserves information richness and supports decision-making by enabling more interactive communication among team members. Therefore, for highly interdependent and complex tasks, it is essential for virtual

team members to use synchronous communication tools, like videoconferencing (Bell & Kozlowski, 2002).

In summary, the role of task interdependence remains double-edged, with researchers adopting various approaches to understand it. However, the antecedent position is in line with the theoretical team effectiveness model structure displayed above (Cohen & Bailey, 1997). Thus, this is the position which is adapted throughout this study.

2.5 Team Communication

Team communication has been the focus of numerous team research papers since decades. It can be defined as an exchange of information between two or more team members (Mesmer-Magnus & DeChurch, 2009). The positive influence of team communication on team performance has been found frequently, both in face-to-face teams and virtual teams (e.g., Salas et al., 2005; Marks et al., 2000; Warkentin & Beranek, 1999). However, it has also been claimed that certain teams do not need overt communication to perform effectively (Burke et al., 2004; Espevik et al., 2006).

A recurring problem and possible reason for these inconsistent findings is the conceptualization of team communication (Stout et al., 1996). It has been studied in different settings such as field and laboratory studies, within various frameworks, and with the inclusion of different variables. Team communication represents a complex research topic and cannot be viewed in an isolated way which is why it has undergone a variety of conceptualizations (Marlow et al., 2018). It can be measured by the extent of knowledge sharing (e.g., Kessel et al., 2012), the frequency with which team members interact with each other (e.g., Bunderson & Sutcliffe, 2003) or the perceived clarity of a received message (e.g., Hoch & Kozlowski, 2014). A differentiation which has frequently been pointed out by researchers is the one of quality versus quantity, or frequency, of communication. Communication frequency refers to the extent of communication occurring among team members whereas communication quality focuses on the extent to which communication within a team is precise and comprehensible. In their empirical study, Marks et al. (2000) found the quality of communication to be a more critical component to team performance than the frequency of communication. Team members can communicate much, however, if the content of what they are saying is not valuable for the team, it does not help with finishing tasks. Meanwhile, less frequent but valuable communication can indeed very much contribute to effectiveness, especially when teams share cognitive representations (Espevik et al., 2006). Consequently, the relationship between frequency of team communication and team performance in the literature has been inconsistent (Marlow et al., 2017). Furthermore, according to Cognitive Load Theory (CLT), an individuals'

working memory capacity is limited up to the extent that outcome processes are hindered by the cognitive load being too high (Sweller et al., 1998). This means that irrelevant information can distract from the relevant parts and therefore impair performance. In this case, frequent communication with partly irrelevant content could hinder team performance at some point rather than have a fully positive relationship (Marlow et al., 2017). Furthermore, in virtual teams, communication volume and therefore cognitive load are considered to be higher due to the constant availability of ICT (DeSanctis & Monge, 1998; Eveland & Dunwoody, 2001). It is therefore argued that communication frequency is not the most suitable way to conceptualize communication and focus of virtual team research should instead be set on the quality of communication (Marlow et al., 2017). Support can be found in a meta-analysis of team communication and team performance by Marlow et al. (2018) where they found the relationship between quality of communication and performance to be significantly stronger than the relationship between frequency of communication and performance. Marks et al. (2000) researched 79 undergraduate teams and declared communication quality as more strongly related to team performance than communication frequency. In both cockpit crews (Oser et al., 1991) and surgical teams (Edmonson, 2003), quality of communication has also been identified as a crucial influence on team performance. Additionally, Shockley et al. (2021) researched remote work due to the COVID-19 pandemic and did not detect an expected curvilinear effect between communication frequency and outcomes while quality of communication was indeed associated with team performance. Therefore, in line with the literature, it can be concluded that communication quality is more significant when studying teams than communication frequency. Overall, quality of communication tends to be more relevant for effective teamwork in traditional face-to-face teams as well as in virtual teams who adapted ICT as a communication tool.

As mentioned before, it is important not to view team communication in an isolated way but to rather include other variables. Both task and team characteristics should be taken into account as they can have an impact on team processes and outcomes (DeChurch & Mesmer-Magnus, 2010). Furthermore, communication can be viewed as the pipeline through which additional variables can happen (Marks et al., 2000). For example, Rico and Cohen (2005) found an interaction effect between task interdependence and synchrony of communication when they investigated 80 virtual teams. Specifically, high interdependence and synchronous communication fostered higher levels of virtual team performance. This underlines the need for high communication quality in virtual teams, especially in combination with highly interdependent tasks. Furthermore, a higher level of synchrony in communication as well as

spontaneous communication helps build a stronger shared identity in virtual teams, which reduces the negative impacts of task and interpersonal conflicts which can arise in geographically dispersed teams (Hinds & Mortensen, 2005).

To date, team communication in hybrid teams has received limited attention from researchers. Given the established importance of team communication for performance in both traditional face-to-face teams and virtual teams, it is reasonable to expect that the quality of communication similarly contributes positively to the performance of hybrid teams. By maintaining a high-quality level of communication, hybrid teams can capitalize on the benefits of face-to-face spontaneity whilst leveraging the structured and deliberate approach often associated with remote collaboration. Quality of communication thus can be expected to play a crucial role in enhancing hybrid team performance. Therefore, taken together the findings of task interdependence as antecedent, and the relationship between quality of communication and team performance, it is hypothesized:

Within hybrid teams, task interdependence is positively associated with quality of communication.

Within hybrid teams, quality of communication is positively associated with team performance.

2.6 Shared Mental Models

Shared mental models represent shared knowledge which includes task-related and team-relevant information contributed by each member (Cannon-Bowers et al., 1993). They have been described as team members' shared, structured comprehension and mental representation of important elements within their relevant environment (Mohammed & Dumville, 2001). Cannon-Bowers et al. (1993) define shared mental models as knowledge structures within a team, allowing its members to develop accurate understandings and expectations about the task, facilitating coordinated actions and adaptive responses to both task requirements and team interactions. Shared mental models focus on the overlap or congruence of individual mental models, specifically, mental models of the task as well as of their team members (Maynard & Gilson, 2014). They enable team members to have knowledge about each other's actions and relevant skills concerning the demands of the task. Maynard and Gilson (2014) summarize the meaning of shared mental models by being "on the same page" (p. 9) with the other team members which both facilitates and accelerates understanding of each other and roots on team cognition. Team cognition is an essential emergent state – a cognitive, motivational, or affective

state of a team – developing from the interactions between team members (Marks et al., 2001). Information about both the task and the team which is shared among team members can be referred to as team cognition (Cannon-Bowers et al., 1993). Espevik et al. (2006) found that knowledge about team members contributes to team effectiveness and diminishes the need for frequent communication.

While communication has always been seen as crucial for team effectiveness (e.g., Marlow et al. 2018), it was only more recently that researchers have acknowledged shared mental models to the extent that they conducted empirical studies exploring this topic (Badke-Schaub et al., 2007). The concept of mental models has been reintroduced to the cognitive science world by Johnson-Laird (1983), specifically in the context of decision-making and reasoning. Mental models on an individual level empower people to understand the world around them by constructing working schemas. Consequently, possessing these schemas on team level facilitates team members in accessing necessary information to make forecasts, comprehend occurrences, and determine appropriate courses of action (Johnson-Laird, 1983). Therefore, if team members exhibit high levels of congruence within their mental models, it facilitates them to understand their team members' actions concerning both the task and the team. They may increase the coordination and effectiveness of the single team members and therefore lead to better performance in tasks that are unpredictable, new, or difficult (Marks et al., 2000).

Cannon-Bowers et al. (1993) have suggested that different team members most probably must share multiple mental models among each other, especially when completing a complex task. Based on this assumption, shared mental models have been classified in subtypes. The most frequent distinction which has been made (e.g., Mathieu et al., 2000; Mathieu et al., 2005) is between task shared mental models and team shared mental models. Task shared mental models indicate that team members possess a mental framework of the task itself, along with an awareness of how environmental factors might influence the task's demands. A shared understanding of task requirements should be essential for effective team performance, and this should happen independently of the communication style within the team. The second subtype, team shared mental models, encompasses the shared understanding among members regarding team operations. For example, team shared mental models might cover decision-making processes, such as whether a team leader will carry out the ultimate call, or which team member to turn to when in need for a certain type of expertise which is needed for the project task. Mathieu et al. (2000, 2005) argue that a combination of task-related shared mental models and team-related shared mental models leads to the best results. To achieve high functionality, team

members must not only be aware of task-related information, but also possess knowledge about their teammates and use this knowledge in order to collaborate effectively.

Team communication has frequently been connected with the concept of shared mental models. Badke-Schaub et al. (2007) state that team members develop the desired overlap of their individual mental models through communication. For example, communication has helped both military (Athans, 1982) and rugby teams (Forgas, 1981) to develop a strong understanding of fellow team members' tactics. Similarly, communication helps to shift members from initial assumptions about each other's expertise to more accurate understandings, shaped by discussions and shared experiences, and develop shared mental models (Yan et al., 2021). Stout (1995) investigated the relationship between team planning and shared mental models and found teams with stronger shared mental models of each other's informational needs to communicate more efficiently. In general, communication is required for highly shared mental models in a team (Stout et al., 1996). Additionally, shared mental models are important in situations where only limited communication is possible (Mathieu et al., 2000). And even if there is no time critical factor, shared mental models can lead to improved communication (Badke-Schaub et al., 2007). Lewis (2003) claims that teams can develop team cognition through a high level of communication quality. Consequently, quality of communication is holding an important role enhancing a team's ability to form common norms and implement cognitive models (Cannon-Bowers et al., 1995). If remotely working teams experience deficient communication, development of collaborative mindsets and shared mental models can be less effective (Burke et al., 1999). Similarly, Olson et al. (2002) note that virtual teams might face a challenge when trying to develop accurate team cognition because they may exhibit a lower quality level of communication due to the geographic dispersion of their members. However, if virtual teams manage to overcome communication challenges and implement a high quality of communication, this might be of great help when exchanging knowledge in order to build shared mental models within the team. Maynard and Gilson (2014) state that irrespective of how communication occurs – in a face-to-face setting or via ICT – team members need a common understanding – shared mental models – to successfully complete their fair share of the team task. Therefore, given the importance of hybrid teams in the modern working environment nowadays, it should be of great interest to find out more about this relationship. Therefore, the following hypothesis has been derived:

Within hybrid teams, quality of communication is positively associated with shared mental models.

Generally, shared cognition has been shown as a driver of team effectiveness (Cannon-Bowers et al., 1993). Over a decade of research has associated shared mental models with a higher level of team performance (Mohammed et al., 2010). DeChurch and Mesmer-Magnus (2010) conducted a meta-analysis and identified a significant, positive relationship between teams' shared cognition and their performance. In their field study of 71 military combat teams, Lim and Klein (2006) found that both team and task shared mental models are a valid predictor for team performance. Mathieu et al. (2000) discovered similar results, with both task and team mental models of face-to-face teams who performed a flight-combat simulation positively relating with their future team processes and team performance. They suggest that shared mental models help team members to foresee each other's responses and ease effective coordination in situations where it might be crucial to act immediately or where no room for long debates or open communication exists. In their meta-analysis, Griepentrog and Fleming (2003) found that shared mental models can be associated with team performance. Singh et al. (2016) state that shared mental models enable team members to anticipate the requirements and behaviors of their colleagues, thereby enhancing overall team performance. Further studies have found a positive association between shared mental models and team performance (e.g., Marks et al., 2000; Marks et al., 2002; Mathieu et al., 2000; Mathieu et al., 2005; Rentsch & Klimowski, 2001; Webber et al., 2000). The latter mainly focused on shared mental models about the task, discovering shared representations about the team's common task as advantaging for team performance. Additionally, Mathieu et al. (2000) and Mathieu et al. (2005) have focused on shared mental models which lay their focus on team interaction processes such as the preferred team member to contact when in need of a relevant skill for the project task. In general, team shared mental models focus on roles and expertise of certain team members which can be viewed as separate mental models from the task-related ones (Maynard & Gilson, 2014). While they were not able to find a significant linear relationship between team shared mental models and team processes or team performance, Mathieu et al. (2005) discovered that team processes and team performance were on a higher level among teams who exhibited task and team mental models of higher quality and a higher level of sharedness. Mathieu et al. (2000) included, as previously mentioned, both task and team shared mental models and found a positive relationship with team performance for both types. Therefore, shared mental models of the team's interaction processes can also be associated with enhanced team performance.

Schmidtke and Cummings (2017) state that shared mental models of teams become more complex with increasing virtuality. Martins et al. (2004) have found mixed results regarding the role of team cognition in virtual teams but have stressed the importance and need

for additional research about this connection. Mohammed et al. (2010) agree and mention the need for more scientific focus on the process of shared cognition development in virtual teams. Algesheimer et al. (2011) were among the first who considered the concept of shared mental models in virtual teams in their research. Maynard and Gilson (2014) have created a theoretical framework which investigates the relationship between shared mental models, task interdependence, and team performance in virtual teams. They argue that shared mental models are one of the most crucial concepts which needs to be included in future virtual team research, especially since virtual teams can consist of the most skilled individuals, unrestricted by time zones or geographic boundaries. Technological capabilities in virtual teams should be aligned accordingly so that shared mental models can be developed suitably. For virtual teams spread across different locations, building a shared mental model is harder (Maynard & Gilson, 2014). However, effective leadership can support knowledge sharing and the development of shared mental models in virtual teams (Liao, 2017). Generally, geographical dispersion of team members and therefore missing personal contact, varying social context, and changing experiences seem to hinder a smooth development of shared mental models due to a higher level of psychological distance (Leonardi et al., 2024). Nevertheless, if shared mental models are well developed, they will help virtual teams to achieve higher team performance, even during complex tasks (Marlow et al., 2017). Finally, the importance of shared mental models is not limited to human teams but extends to collaborations of humans and artificial intelligence (AI), as proposed by Andrews et al. (2023). According to the authors, applied shared mental model understanding of human teams is expected to result in enhancements in human-AI teaming where a team is formed of both humans and artificial intelligence.

Due to the strong impact shared mental models have on team outcomes in both traditional face-to-face-teams and in virtual teams, it can be expected that they also play a role in successful hybrid teamwork. Teams who communicate both online and face-to-face may face situations in which interacting with certain team members is easier than with others. During a meeting where a part of the team is physically present, and another part is joining online, a great overlap of shared mental models could ease the understanding and diminish the time needed for explanation, making room for more efficient meetings. This could be especially helpful for the remote team members as they might not understand every word which is spoken face-to-face, or they might experience a lack of recognizing details in mimics and gestures from their face-to-face colleagues. Therefore, shared mental models – which enable to be on the same page with your team members – could present themselves as helpful in these situations. Furthermore, less time would have to be taken in order to explain certain actions, diminishing

necessary communication as well. In total, it can be expected that shared mental models have an influence on team performance. Thus, taking together these findings with those of task interdependence serving as antecedent of team process, I hypothesize:

Within hybrid teams, task interdependence is positively associated with shared mental models.

Within hybrid teams, shared mental models are positively associated with team performance.

3 Research Question and Hypotheses

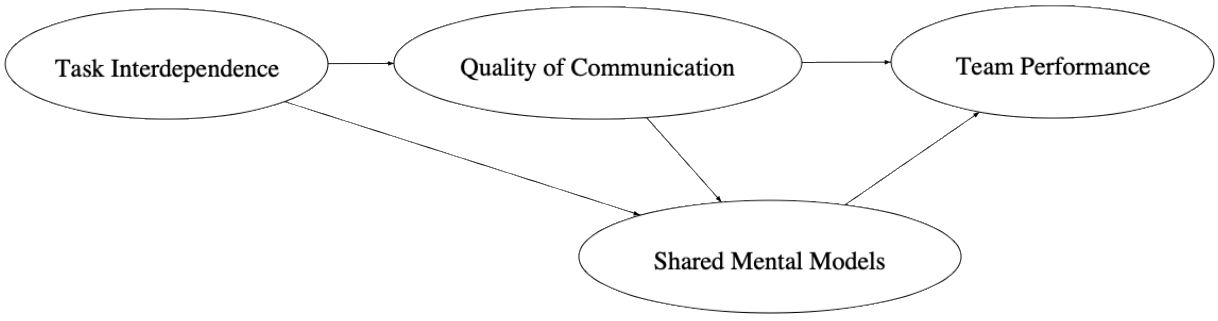
In the previous chapter, relationships between interdependence, communication, shared mental models, and team performance have been hypothesized. To date, little research has been conducted concerning these concepts in hybrid teams. Therefore, on the basis of the aforementioned theoretical considerations, the aim of this thesis is to fill the described gap in research by focusing on hybrid teams.

Consequently, derived from previous research, the following research question has been formulated: How do task interdependence, quality of team communication, and shared mental models relate to the team performance of hybrid teams?

This research question can be visually depicted in the following theoretical model of team effectiveness in hybrid teams (see Figure 1):

Figure 1

Theoretical Model of Team Effectiveness in Hybrid Teams



To give an overview, the derived hypotheses presented after the respective theoretical background are summarized here and will undergo further statistical analyses throughout the thesis. The numbering of the hypotheses resembles the I-P-O approach rather than the order of appearance in the theoretical background.

H1: Within hybrid teams, task interdependence is positively associated with quality of communication.

H2: Within hybrid teams, task interdependence is positively associated with shared mental models.

H3: Within hybrid teams, quality of communication is positively associated with team performance.

H4: Within hybrid teams, quality of communication is positively associated with shared mental models.

H5: Within hybrid teams, shared mental models are positively associated with team performance.

4 Materials and Methods

4.1 Study Design and Procedure

Study data were collected from six student classes at the TU Wien (Vienna University of Technology) and the Sigmund Freud Private University Vienna (SFU) during the summer semesters of 2021, 2022, and 2023. Three classes took place at TU while three were organized at SFU. As part of their grading, the students had to create a group presentation which they gave to their peers as well as the seminar leader. Furthermore, students had to complete two surveys reflecting their teamwork. The first one was presented at the beginning of the teamwork task, and the second one right after the group presentation which marked the end of their teamwork. At both universities, the course's format was a block seminar, meaning it took place several hours per day but not over the weekly span of a whole semester. In the case of TU, the class took place over a span of 1.5 months, while at SFU, it finished within a week. Group presentations at TU covered topics related to Human Resource Management and Leadership while those at SFU similarly covered topics associated with organizational, occupational, coaching, or personnel psychology. Students at TU were part of the master's program of mechanical engineering and management, students at SFU could choose the class as a free elective and studied psychology in their Bachelor's or Master's. Seminar leaders differed between the two universities but continued to hold the seminar during the years of 2021, 2022,

and 2023 at their respective university. Furthermore, they stayed in constant exchange concerning both content and structure of the class.

Data collection happened online via EFS Survey/Unipark (QuestBack GmbH, 2020). Data were collected independently of and previously to this thesis. Therefore, the survey design, sample size, and measurement scales have all been chosen externally. Students of all six courses formed teams to complete the group presentations. During the course, they participated in the mandatory seminar sessions while implementing additional meetings with their team to prepare the presentations. These sessions and meetings happened both in person and online which set the conditions for hybrid teams.

Several concepts of team research were included in the two surveys, of which some were collected at both times and some only once. It is important to note that this study focuses on a selection of the surveyed concepts only. Further analyses with more concepts are explicitly desired. However, the analysis of all concepts would go beyond the scope of this study. A complete list of all surveyed concepts can be found in the codebook of this study.

For the present study, task interdependence data have been consulted from the first survey, just after the teamwork had started but before the presentations took place. Data which measured quality of communication, shared mental models, and team performance were all derived from the second survey which has been completed after the final presentations. Individual team data have been aggregated per team. Thus, analyses of the hypotheses happened on the team level.

All students could voluntarily participate in the survey while furthermore having the option of finishing an alternative task instead. Students received course credits for participation in the survey which eventually led to a better grade. However, in order to be considered for the course credits, the whole team had to complete the survey.

4.2 Sample

Study participants include $N = 536$ students who formed $N = 127$ teams in total. Each team consisted of three to five members. The minimum team size of three creates the possibility of more complex interpersonal interactions compared to dyads (Kozlowski & Ilgen, 2006). Classes at SFU were larger with 30 teams in 2021, 29 teams in 2022, and 28 teams in 2023 than classes at TU with 15 teams in 2021, 12 teams in 2022, and 13 teams in 2023. In total, 205 students of TU and 331 students of SFU participated in the surveys. Because of minor dropouts, the second survey was filled out by 519 students only.

14 teams of the TU class of 2021 exceeded the individual replies of five. Concretely, the information that the whole team had to complete the survey in order to be considered for

additional course credits led to insecurity among several students if they had already completed the survey. As a consequence, a misunderstanding occurred which led to double completion of the survey to ensure that they were considered for additional course credits. No unique identifier as individual matching variable was included during this class. Hence, it was impossible to ensure correct exclusion of individual cases. Consequently, these teams were not included in subsequent analyses. After this exclusion, individual replies resulted in n = 435 in the first survey, and n = 407 in the second survey. On team level, the remaining 113 teams consisted of three (n = 21; 18.6%), four (n = 80; 70.8%), and five (n = 12; 10.6%) members. All following demographic sample descriptions are therefore made with the aforementioned baselines.

The vast majority of the participants were in their twenties (n = 396; 96.6%) which accurately represents a typical student sample. The youngest person was 19 years old, the oldest 65, while 96.8% (n = 397) out of all 435 individuals were younger than 30, and 99.0% (n = 406) younger than 40. 25 participants did not fill out their age which is why percentages and absolute values were derived from a total size of n = 410.

Similarly, participants did not show major differences at their education levels. Five participants did not report their education level. For the rest, *AS/A level or equivalent* (n = 155; 36.0%), and *Bachelor's degree* (n = 107; 24.9%) were the most frequently selected options. Other options were *No qualification* (n = 19; 4.4%), *Entry level qualification* (n = 70; 16.3%) – which may have caused some confusion with *AS/A level or equivalent – O level, RSA diploma, apprenticeship etc.* (n = 29; 6.7%), *RSA higher diploma or other higher qualification below degree level* (n = 44; 10.2%), *Master's degree or equivalent* (n = 5; 1.2%), and *Doctorate/PhD or equivalent* (n = 1; 0.2%).

Gender distribution on the individual level shows with n = 261 (60.1%) *female*, n = 161 (37.1%) *male*, n = 2 (0.5%) *non-binary*, and n = 10 (2.3%) *no information* a slight tendency towards female overrepresentation. On the team level, 16 teams (14.2%) consisted of *male only* members, nine teams (6.2%) of *almost male only* members, 32 teams (28.3%) of *female only*, 28 teams (24.8%) of *almost female only*, and 30 teams (26.5%) of members with *balanced gender distribution*. Criteria for the *almost male only* and *almost female only* categories were the same gender for all members but one. The decision of this categorization has been made due to the gender distribution among the two universities. While 15 out of 16 *male only* and four out of the seven *almost male only* teams are from one of the TU classes, all 32 *female only* and 28 *almost female only* teams took part in a SFU class. The Master's program of mechanical engineering and management at TU has predominantly male students while female students dominate at the psychology tracks of SFU.

Students at TU had the option to choose the survey language. While their Master's Program is offered in German language, the majority (n = 75; 72.1%) chose to fill in the questionnaire in German language, and n = 29 (27.9%) chose English language. At SFU, the psychology track is offered in English language and therefore attended by many internationals. Hence, the questionnaire was offered and completed in the English version only.

4.3 Missing Data

A small number of missing values was found in the demographic data, as mentioned above. However, these did not have any influence on further analyses. All items referring to task interdependence, quality of team communication, shared mental models, or team performance were marked as obligatory in the questionnaire. Hence, no missing data appeared for any of their items.

4.4 Data Exclusion

As mentioned above, redundant replies in the TU class of 2021 occurred. Due to the absence of a matching variable, identifying them has proven to be a challenge, which in turn made the exclusion of 14 teams necessary to avoid biased results. No further need to exclude data from the dataset appeared, therefore, no further measures were taken.

4.5 Measures

Four concepts of team research were included in the analysis, namely task interdependence, quality of communication, shared mental models, and team performance.

4.5.1 Task Interdependence

Task interdependence was measured by three items in the first survey only using the *task interdependence scale* by van der Vegt et al. (2001). Items were measured on a 5-point Likert scale, reaching from 1 = *completely disagree* to 5 = *completely agree*. Therefore, higher scores refer to a higher perceived level of task interdependence. A Cronbach's alpha value of .741 showed acceptable reliability (Blanz, 2015). The items are displayed in Table 1.

Table 1

Task Interdependence Scale Items

Item name	Item wording of *task interdependence scale* (van der Vegt et al., 2001)
INT1	I have to obtain information and advice from my colleagues in order to complete my work
INT2	I depend on my colleagues for the completion of my work
INT3	I have to work closely with my colleagues to do my work properly

4.5.2 Quality of Communication

In both surveys, measuring quality of communication happened through the dimension of focused communication as part of the *team communication scale* by Hartner-Tiefenthaler et al. (2022), based on Gittel (2011). The scale includes three sub-dimensions, namely shared knowledge, focused communication, and spontaneous communication, each consisting of three items. Responses were given based on a 5-point Likert scale with values from 1 = *strongly disagree* to 5 = *strongly agree*. Consequently, higher scores of the scale indicate a higher level of perceived quality of communication. As the first survey was handed out at an early stage of their team collaboration, several students expressed their concern about the validity of the results. For this reason, quality of communication data from the second survey was used for this study. Good reliability of the scale could be shown by a Cronbach's alpha score of .865 (Blanz, 2015). All three items of the scale are depicted in Table 2.

Table 2

Quality of Communication Items

Item name	*Focused communication* item wording of *team communication scale* (Hartner-Tiefenthaler et al., 2022)
QCOMM1	In our team, we communicate in a timely manner.
QCOMM2	In our team, we communicate exactly and precisely.
QCOMM3	In our team, we communicate result oriented.

4.5.3 Shared Mental Models

Shared mental models (SMM) data have been collected at both surveys. For this purpose, team and task SMM were measured by three items each while being treated as one scale with six items thereafter. Items were adapted from Konradt et al. (2015). The responses were given on a 5-point Likert scale ranging from 1 = *disagree* to 5 = *agree*. This indicates a higher level of perceived sharedness of mental models for higher scores. Due to similar reasons as with the quality of communication scale – the first survey being handed out at a very early stage of the teamwork – SMM data from the second survey were analyzed. A Cronbach's alpha value of .909 for SMM (.878 for team SMM only; .891 for task SMM only) showed excellent reliability (Blanz, 2015). All six items can be found in Table 3.

Table 3

Shared Mental Models Items

Item name	Item wording (adapted from Konradt et al., 2015)
teamSMM1	During our group project, we knew the skills and competences of the other team members which is relevant for the project task.
teamSMM2	During our group project, we knew who has special skills and expertise that are important for working on the project task.
teamSMM3	During our group project, we knew how we allocate tasks and roles in our team.
taskSMM1	During our group project, we knew our team goals and progress we pursue in working on the project task.
taskSMM2	During our group project, we knew the strategies that our team follows in task execution.
taskSMM3	During our group project, everyone knew how the task relevant knowledge of the members and the project task relate to each other.

4.5.4 Team Performance

Self-reported team performance was measured using a nine-item scale by Griffin et al. (2007), building on their model of work role performance. This construct was measured at the second survey only, after the student teams' presentations, and before receiving the information about their grades. Using a 5-point Likert scale, values reached from 1 = *very little* to 5 = *a great deal*. That is, equal to all previous scales, higher values indicate a higher level of perceived team performance. Cronbach's alpha reached a value of .955 which indicates excellent reliability (Blanz, 2015). All nine items are displayed in Table 4. The self-reported team performance was used to test the hypotheses.

Both seminar leaders externally rated the teams' presentations by assigning course credits. At TU, the score was a single number with a maximum score of 45% (of the final grade). At SFU, the score consisted of two subscores *content* and *form*, adding up to a total score of maximum 25% (of the final grade). Due to a different rating system, no external team performance ratings are available for n = 28 teams of the SFU 2023 class. For measurement reasons, the external performance rating was only assessed during exploratory analysis.

Table 4

Team Performance Items

Item name	Item wording (Griffin et al., 2007)
PERF1	How often have team members coordinated their work with coworkers?
PERF2	How often have team members communicated effectively with their coworkers?
PERF3	How often have team members provided help to coworkers when asked, or needed?
PERF4	How often have team members dealt effectively with changes affecting your work unit (e.g., new members)?
PERF5	How often have team members learnt new skills or taken on new roles to cope with changes in the way your unit works?
PERF6	How often have team members responded constructively to changes in the way your team works?
PERF7	How often have team members suggested ways to make your work unit more effective?
PERF8	How often have team members developed new and improved methods to help your work unit perform better?
PERF9	How often have team members improved the way your work unit does things?

4.6 Analytic Strategy

4.6.1 Data Screening

Data have been screened for several characteristics. First, multivariate normality of the variables was tested by conducting Kolmogorov-Smirnov tests. The results indicated that task interdependence was normally distributed, $D(113) = .05$, $p = .200$. However, quality of communication, shared mental models, and team performance significantly deviated from normality ($D(113) = .17, p < .001$; $D(113) = .10, p = .008$; $D(113) = .13, p < .001$, respectively). Hence, results indicate issues with normal distribution. Histograms can be found in Appendix A. Additionally, normality was tested by looking at the skewness and kurtosis of each single item. Skewness indicates the level of symmetry of a variable's distribution while kurtosis measures the tailedness (Field, 2017). Hair et al. (2022) suggest cut-offs of + 2 and - 2, indicating that skewness and kurtosis values within this number span represent normally distributed data. Here, *taskSMM3* just managed to stay below the cut-off for skewness, still

indicating the possibility of an asymmetric distribution. In general, frequent left-skewed distributions show a tendency towards higher scores compared to lower scores. Furthermore, 10 items exceed the cut-off for kurtosis, indicating violation of normal distribution. Due to the central limit theorem, it can be credibly proceeded with $N > 30$ (Field, 2017). Generally, multivariate normality in psychology is rather rare. However, in line with the significant Kolmogorov-Smirnov tests, these results must be taken into consideration during further analyses. Normality results can be found in Table 5.

Table 5

Skewness and Kurtosis Normality Testing

Item	Skewness	Standard error	Kurtosis	Standard error
INT1	0.32	0.23	0.11	0.45
INT2	-0.06	0.23	-0.30	0.45
INT3	0.24	0.23	0.40	0.45
QCOMM1	-1.34	0.23	1.87	0.45
QCOMM2	-1.35	0.23	2.70	0.45
QCOMM3	-1.18	0.23	0.92	0.45
teamSMM1	-0.41	0.23	-0.26	0.45
teamSMM2	-1.06	0.23	2.57	0.45
teamSMM3	-0.61	0.23	-0.12	0.45
taskSMM1	-0.95	0.23	1.32	0.45
taskSMM2	-0.89	0.23	0.82	0.45
taskSMM3	-1.99	0.23	7.50	0.45
PERF1	-1.19	0.23	2.70	0.45
PERF2	-1.58	0.23	3.07	0.45
PERF3	-1.86	0.23	6.16	0.45
PERF4	-1.37	0.23	4.14	0.45
PERF5	-0.58	0.23	1.00	0.45
PERF6	-1.83	0.23	6.10	0.45
PERF7	-1.42	0.23	3.87	0.45
PERF8	-1.00	0.23	2.80	0.45
PERF9	-0.66	0.23	0.70	0.45

Approximately elliptical and rather homoscedastic bivariate scatterplots comparing quality of communication with shared mental models, quality of communication with team performance, and shared mental models with team performance suggest similar residual variance between those three pairings. However, task interdependence in combination with any of the three other constructs resulted in a heteroscedastic scatterplot, indicating absence of bivariate normality. See Appendix B for graphical depiction.

For two reasons, univariate outliers were not excluded. First, the sample size would have decreased further. This will be picked up in the limitations section. Second, removing univariate outliers on a 5-point Likert scale might be irrelevant as extreme responses may reflect valid variation rather than errors.

4.6.2 Statistical Procedure

For analyzing the postulated relationships, the mean value of all individual responses has been calculated per team for all measured items and constructs, hence, representing the team value. The four constructs task interdependence, quality of communication, shared mental models, and team performance represent latent variables which are measured by manifest items on a metric scale level. This structure allows for path analysis with latent constructs and manifest variables (Sarstedt et al., 2021). Therefore, partial least squares structural equation modeling (PLS-SEM) has been chosen as analysis method. Compared to covariance-based SEM, PLS-SEM approach can handle nonnormal distributed data and small sample sizes (Hair & Alamer, 2022).

The present study measures independent and dependent variables via self-reports. Hence, common method bias could occur. Kock (2015) postulated that common method bias in PLS-SEM can be assessed via the variance inflation factor (VIF) which is otherwise known for collinearity testing. According to the author, VIFs below 3.3 indicate the absence of common method bias. In the present study, no VIF exceeds this threshold, postulating no major harm of possible common method bias. However, measurement by self-reports should stay in the back of the head when analyzing the results.

4.6.3 Decision about Inclusion of Control Variables

Prior to the main analyses, possible confounding influences of several variables must be checked. Those variables are the university (which differs regarding lecturer and length of cooperation), number of members (team size), and gender distribution within a team. Multiple regression analysis with team performance as outcome was performed. Predictors were quality of communication, shared mental models, university, team size, and gender distribution. Results indicate a significant model, $F(5, 112) = 63.18$, $p < .001$ (two-tailed). Specifically, both quality

of communication (β = .53, *SE* = .08, *p* < .001) and shared mental models (β = .40, *SE* = .08, *p* < .001) are significantly positive predictors of team performance, while university (β = .11, *SE* = .07, *p* = .064), team size (β = .01, *SE* = .02, *p* = .864), and gender distribution (β = -.07, *SE* = .02, *p* = .251) are not. Hence, it was not necessary to control for any of the possibly confounding variables during subsequent analyses.

4.6.4 Software

All preparation and prerequisite data analyses were conducted using IBM SPSS Statistics (Version 29). PLS-SEM was completed via JASP (Version 0.19.3). JASP employs a user-friendly drag-and-drop technique while allowing for real-time feedback output changes through adjusting options (Love et al., 2019). For the method of PLS-SEM, in comparison to other software, JASP combines the advantages of user-friendly performance, free access, and high transparency of adapted changes (Rogers & Barboza, 2024).

5 Results

The following chapter addresses descriptive statistics and the procedure of performing PLS-SEM in order to assess the hypotheses. Descriptive statistics of the four constructs can be found in Table 6.

All analyses were conducted on team level. As mentioned, data of all four constructs were collected on a 5-point Likert scale before being aggregated to a team score. For the team score, the mean value of the aggregated individual scores was calculated.

Table 6

Descriptive Statistics of the Constructs

Variable	*M*	*SD*	1	2	3
1. Task interdependence	2.86	0.57			
2. Quality of communication	4.45	0.45	-.04		
3. Shared mental models	4.19	0.46	-.07	.66**	
4. Team performance	4.18	0.53	-.10	.79**	.76**

Note. *N* = 113. **p < .01.

5.1 Measurement Model

Several steps should be considered to assess the reflective measurement model of PLS-SEM (Hair & Sarstedt, 2020). As the data deviate from normality, bootstrapping of 5000 samples is recommended when conducting PLS-SEM (Hair & Alamer, 2022), which was therefore applied to all subsequent analyses. Indicator loadings are desired to exceed a value of

.7 while .6 or higher is still considered as acceptable (Rogers & Barboza, 2024). The majority of indicator loadings score above .7 except for *teamSMM2*, *INT1*, *INT2*, and *INT3*. However, Hair et al. (2019) have justified loadings from .4 to remain in the model if other indices score acceptable values, which is why no indicator was excluded at this point. All loadings can be found in Table 7.

Table 7

Indicator Loadings of all Theoretical Constructs and their Respective Items

Theoretical construct	Item	Indicator loading
Task interdependence	INT1	.410
	INT2	.527
	INT3	.521
Quality of communication	QCOMM1	.853***
	QCOMM2	.869***
	QCOMM3	.752***
Shared mental models	teamSMM1	.741***
	teamSMM2	.602***
	teamSMM3	.847***
	taskSMM1	.808***
	taskSMM2	.846***
	taskSMM3	.907***
Team performance	PERF1	.857***
	PERF2	.918***
	PERF3	.807***
	PERF4	.787***
	PERF5	.791***
	PERF6	.859***
	PERF7	.885***
	PERF8	.770***
	PERF9	.781***

Note. ***$p < .001$.

To reach internal consistency, Cronbach's alpha should exceed a score of .70 (Hair et al., 2010). As calculated in the previous chapter, this is present in all four constructs of the data.

To assess construct validity, both convergent validity and discriminant validity should be considered (Campbell & Fiske, 1959). Convergent validity indicates that a construct is adequately measured by its indicators, while discriminant validity ensures that the individual tests in a model are distinct and measure different constructs. Convergent validity requires the calculation of average variance extracted (AVE) per construct. AVE can be calculated by dividing the sum of squares of each loading by the number of indicators of the respective construct (Hair et al., 2010). AVE results can be found in Table 8. For convergent validity, AVE of each scale should exceed .50 (Hair et al., 2010). AVE measures of quality of communication, shared mental models, and team performance exceeded .5, indicating fulfillment of convergent validity requirements for these constructs, and further allowing for inclusion of the item *teamSMM2*. However, as all three task interdependence items score below .7 in their loadings, their AVE scores below .5 which does not indicate convergent validity of this construct.

Table 8

Convergent Validity of Measurement Models

Construct	Σ loading^2	Number of indicators	AVE
Task interdependence	0.717	3	.239
Quality of communication	2.048	3	.683
Shared mental models	3.820	6	.637
Team performance	6.197	9	.689

Table 9

Discriminant Validity of Measurement Models

Constructs	HTMT
TI <-> QC	.057
TI <-> SMM	.080
TI <-> TP	.085
QC <-> SMM	.735
QC <-> TP	.844
SMM <-> TP	.815

Note. TI = Task interdependence, QC = Quality of communication, SMM = Shared mental models, TP = Team performance.

For discriminant validity, heterotrait-monotrait ratio (HTMT) should be lower than .85 for constructs that are conceptually different (Hair & Alamer, 2022). All HTMT values score below .85 which indicates that discriminant validity is achieved (see Table 9 for results). Thus, construct validity can be considered as given in the constructs quality of communication, shared mental models, and team performance. Task interdependence fulfills the requirements for internal consistency and discriminant validity but does not meet the threshold of AVE which is why the decision was made to exclude this concept from further analyses. Similarly, this leads to rejection of hypotheses 1 and 2 as no further assessment of the respective path coefficients was possible.

5.2 Structural Model

In order to test the hypotheses 3, 4, and 5, the structural model of PLS-SEM has been examined. Due to previous exclusion of task interdependence, the structural model included quality of communication, shared mental models, and team performance as latent constructs. Steps were again derived by Hair et al. (2020), and bootstrapping with 5000 samples has again been conducted (Hair & Alamer, 2022) as it ensures robust statistical analyses (Rogers & Barboza, 2024). To avoid single correlations which are too high and result in subsequent methodological issues, multicollinearity had to be ruled out. Variance inflation factor (VIF) should not reach a value above 5, or better, above 3 (Hair & Sarstedt, 2020). Here, VIF values stayed below 3 (2.25; 2.25), indicating no violation of multicollinearity.

Next, standardized path coefficients were calculated. In order to receive the *p*-value and bias-corrected confidence intervals, bootstrapping with 5000 samples has again been conducted (Hair & Alamer, 2022). This ensures robust statistical analyses (Rogers & Barboza, 2024). According to the path coefficient results, hypotheses 3, 4, and 5 can all be supported. Detailed results can be found in Table 10. Furthermore, effect sizes can be categorized by Cohen (1988) who postulated values above 0.02, 0.15, and 0.35, respectively, to represent small, medium, and large effects. Consequently, the present effect sizes indicate a large effect for the path coefficients representing H3 ($f^2 = 0.81$), H4 ($f^2 = 1.25$), and H5 ($f^2 = 0.38$).

Next, the coefficient of determination should be assessed. The explained variance (R^2) values for the constructs in the model provide an indication of in-sample predictive power (Hair & Alamer, 2022). Results show that a substantial portion of the variance in shared mental models is explained by quality of communication ($R^2 = .556$), indicating a moderate to strong explanatory relationship. Similarly, team performance demonstrates a high level of explained variance ($R^2 = .819$), which reflects a strong influence of the predictors on this outcome variable.

Table 10

Structural Model Results

Hypothesis	Relationship	Standardized path coefficient	Standard error	95% confidence interval
H3	QC → TP	.567***	.12	[0.34, 0.78]
H4	QC → SMM	.739***	.07	[0.59, 0.86]
H5	SMM → TP	.400***	.11	[0.17, 0.62]

Note. QC = Quality of communication, SMM = Shared mental models, TP = Team performance.

****p* < .001

Table 11

Out-of-Sample Predictive Power

Indicator	Target RMSE	Linear model RMSE	Target $Q^2_{predict}$
teamSMM1	0.544	0.561	0.235
teamSMM2	0.643	0.672	0.125
teamSMM3	0.461	0.472	0.317
taskSMM1	0.349	0.399	0.327
taskSMM2	0.410	0.428	0.344
taskSMM3	0.478	0.467	0.373
PERF1	0.415	0.417	0.492
PERF2	0.409	0.408	0.560
PERF3	0.400	0.409	0.429
PERF4	0.453	0.455	0.426
PERF5	0.511	0.514	0.332
PERF6	0.465	0.464	0.449
PERF7	0.466	0.473	0.510
PERF8	0.537	0.532	0.357
PERF9	0.524	0.528	0.354

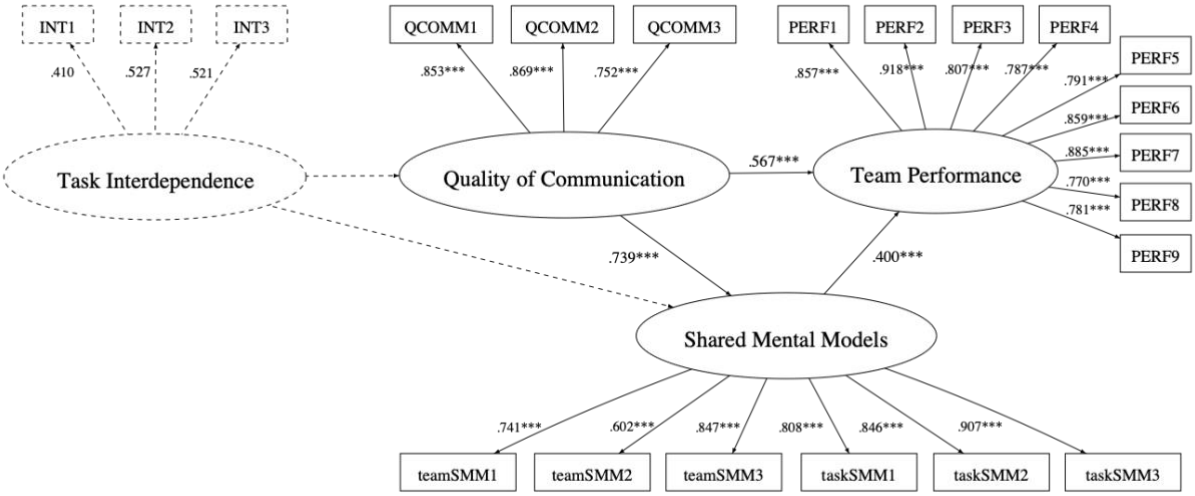
Out-of-sample predictive power, that is, external validity, should additionally be assessed (Hair et al., 2020). Root mean squared error (RMSE) indicators of the PLS-SEM have been compared with those of a linear regression model and should be lower in the PLS-SEM (Hair & Alamer, 2022). For the present data, RMSE measures are mostly lower in the PLS-

SEM compared to the linear regression model. For items *taskSMM3*, *PERF2*, *PERF6*, and *PERF8*, RMSE measures score just higher in the PLS-SEM. However, cross-validated redundancy should also be assessed by looking at the PLS-SEM $Q^2_{predict}$ prediction (Rogers & Barboza, 2024). If these values result above zero, it is an indicator of out-of-sample predictive power. In the present data, all $Q^2_{predict}$ values score above zero, indicating presence of out-of-sample predictive power (Rogers & Barboza, 2024). Detailed results can be found in Table 11.

The final PLS-model, including indicator loadings and path coefficients, can be viewed in Figure 2. It is a frequent practice to display latent constructs in circular shapes and observed variables in rectangular shapes. Hence, square graphics represent the observed items measuring the latent constructs. Each latent construct is represented by a circular graphic. On each one-headed arrow leading from a latent construct towards an observed variable, the respective loading is displayed. On each one-headed arrow leading from one latent construct to another, the calculated path coefficients are presented. An exception is task interdependence which was excluded from the structural model after assessing the measurement model. Therefore, it was not possible to calculate valid path coefficients. Exclusion of task interdependence is graphically depicted by dotted lines.

Figure 2

PLS-SEM of Team Effectiveness in Hybrid Teams



Note. Straight lines represent significant loadings or path coefficients. Dotted lines represent nonsignificant or excluded loadings or path coefficients.

***$p < .001$.

5.3 Exploratory Analysis

In addition to the confirmatory analyses, exploratory analyses were conducted. It is important to note that, given the variety of concepts measured in the survey, infinite exploratory analyses could have been performed. However, exploring further concepts which have not been substantially addressed in the theoretical background is preferably left to future studies.

5.3.1 External Team Performance Rating

As previously mentioned, team performance was not only self-reported by the students, but also externally rated by both seminar leaders. For the reason of measurement inequality between the two universities and the measure of *form* in SFU teams, it was excluded from the confirmatory analyses of hypotheses. However, exploring the relationship of quality of communication and shared mental models with the external rating can still be insightful and serve as a robustness test.

Multiple regression analysis has been performed. Results indicate a significant explanation of variance of quality of communication and shared mental models by externally rated team performance, $F(2, 84) = 2.82$, $p = .033$ (one-tailed). Specifically, the positive effect of quality of communication on externally rated team performance was significant ($\beta = .28$, $SE = 1.04$, $p = .020$, one-tailed), the positive effect of shared mental models not ($\beta = -.05$, $SE = 1.01$, $p = .351$, one-tailed).

5.3.2 Variance of Constructs on Team Level

While hypotheses testing required calculation of the mean value of each team's individual responses, exploratory analysis of the variance of these responses can give further insights. Variance of both quality of communication and shared mental models within the team were tested for predicting team performance. Multiple regression analysis revealed a significant overall model, $F(2, 103) = 28.84$, $p < .001$ (two-tailed). Both variance of quality of communication ($\beta = -.50$, $SE = .08$, $p < .001$, two-tailed) and variance of shared mental models ($\beta = -.18$, $SE = .06$, $p = .040$, two-tailed) resulted in significant negative association with team performance.

6 Discussion

6.1 General Discussion

The purpose of this study was to understand how quality of team communication and shared mental models relate to team performance in hybrid teams, and whether task interdependence shapes the perception of team communication and shared mental models.

The first and second hypotheses postulate a positive association between task interdependence and quality of communication, and between task interdependence and shared

mental models. However, due to methodological issues, that is, low item loadings and lack of convergent validity, task interdependence has been excluded from the structural model. Hence, it was not feasible to assess a possible significantly positive association of task interdependence with quality of communication in hybrid teams, as proposed by the first hypothesis. Similarly, it was not possible to test for a significantly positive association between task interdependence and shared mental models in the data. Consequently, the first and second hypotheses have been rejected. Measurement of task interdependence can serve as an explanatory approach. The hybrid student teams have completed similar types of tasks which may have resulted in little objective difference of task interdependence, and thus, in lack of construct validity. These results cannot be associated with the antecedent position of task interdependence, as proposed by Cohen and Bailey (1997) in their team effectiveness model. They categorize task interdependence as a task design factor, providing tools for further processes. The present theoretical model has referred to this approach. Therefore, it has employed task interdependence as an input factor, and thus, the antecedent of further team processes. However, due to methodological shortcomings, the antecedent position of task interdependence was not further investigated. Mixed findings in the literature provide further space for possible explanations. Studies by Wageman (1995) and Zhou (2017) postulate the influence of task interdependence on internal team processes. Other literature treats it as a moderator (e.g., Marlow et al., 2018), or even as a direct predictor of team performance (Hertel et al., 2004). Hence, the role of task interdependence remains unclear.

Testing the third hypothesis, a significant positive association between quality of communication and hybrid team performance has been detected. This result is in line with literature researching face-to-face teams, for example two meta-analyses by Mesmer-Magnus and DeChurch (2009) and Marlow et al. (2018) who both found a significantly positive prediction of team communication on team performance. Marlow et al. (2018) further highlighted the importance of communication quality in this relationship. This consensus indicates the value of good team communication quality, emerging in face-to-face teams but equally kept in mind in hybrid team settings.

The fourth hypothesis proposed a positive association between quality of communication and shared mental models in hybrid teams. This relationship was found to be significantly positive, and thereby supports the present literature, for example Badke and Schaub (2007) who have highlighted the necessity of high quality of communication in order to build shared mental models. It is further in line with Cannon-Bowers et al. (1995) who have emphasized the need of high communication quality to ensure a team's ability to develop shared cognitive models.

Finally, shared mental models in hybrid teams have been found to be significantly positively associated with team performance, as postulated by the fifth hypothesis. This result is supported by the literature which suggests a positive relationship between shared mental models and team performance in face-to-face teams, for example the meta-analysis by DeChurch and Mesmer-Magnus (2010), the paper by Griepentrog and Fleming (2003), or the field study by Lim and Klein (2006). Marks et al. (2000) found this relationship especially for new tasks which has equally been the case in the current study. As both team and task shared mental models have been included in the present research, the results are furthermore in line with Mathieu et al. (2000) who have underlined the relationship between shared mental models and team performance for both task and team shared mental models. The consistency in the results between previous literature and the current study indicates the importance of the presence of shared mental models not only in face-to-face teams but also in hybrid teams.

Therefore, the positive relationships between quality of communication, shared mental models, and team performance provide reason to adopt certain characteristics of the team effectiveness model by Cohen and Bailey (1997) for hybrid team settings. Quality of communication as team process positively relating to shared mental models as group psychological trait, and both of these positively relating to team performance as an outcome demonstrate similar connections in a hybrid setting compared to the initial face-to-face setting in which the model was created.

In addition to the confirmatory results, exploratory analyses provide further insights into the data. First, external team performance ratings have been examined. Results indicate an overall significant positive explanation of variance in both quality of communication and shared mental models through externally rated team performance. When examining the predictors separately, the effect of communication quality on external team performance remained significant while the effect of shared mental models did not. A reason for this result could lie in a possible difference in the performance perception of the students versus the lecturers. It may be an example of overconfidence bias where students have rated their performance better than it actually was. On the other hand, lecturers have only seen the final presentation and have partly included the form of the presentation in their rating which was not assessed from the students.

Analyses have been conducted on team level as the group effect was of interest. For this, the mean value of individual responses represents the team score. However, it is also of interest if team members have the same impressions of their communication quality, their level of shared mental models, and their team performance. This could be an indicator on how well the

group works together. Therefore, variance of the aggregated team scores of quality of communication and shared mental models was analyzed during exploratory analyses. Results indicate that variance in both quality of communication and shared mental models responses on team level has a negative influence on team performance. That is, if team members have all given similar responses regarding their team's perceived quality of communication and shared mental models, it led to higher performance than if their responses differed. Thus, team synergy seemed to play a role in the level of team performance.

The significant positive relationship between quality of communication and team performance demonstrates that the quality of team communication seems to be a crucial aspect of successful hybrid team performance. To date, most support from team literature can be derived from face-to-face settings where quality of communication has been widely acknowledged to have a positive effect on team performance (e.g., Marlow et al., 2018; Mesmer-Magnus & DeChurch, 2009). Furthermore, as Marlow et al. (2017) have already postulated for fully virtual teams, it is highly recommended to focus on the quality rather than the frequency of communication when including information communication technology (ICT). Team members communicating via ICT constantly experience a high cognitive load which makes their working memory capacity reach its limits quicker (DeSanctis & Monge, 1998; Eveland & Dunwoody, 2001). Now, within hybrid teams, team members communicate both via ICT and in person. Being confronted with different levels of physical proximity, the unique dynamics of hybrid teams may lead to new challenges. However, the results indicate that despite these challenges, teams that prioritize high-quality communication can overcome potential barriers and thereby enhance their performance.

Additionally, shared mental models have a positive association with team performance in hybrid teams. Specifically, both task and team shared mental models seem to be of relevance, as already proposed for face-to-face teams by Mathieu et al. (2000). These findings build on the postulated relationship between shared mental models and team performance in face-to-face teams (e.g., Marks et al., 2000; Marks et al., 2002; Rentsch & Klimowski, 2001; Webber et al., 2000). Hybrid team members who are on the same page about their task characteristics such as deadlines, and their team characteristics such as who has certain expertise have good chances to perform higher in comparison to the scenario where their individual mental models of these characteristics do not overlap sufficiently.

After assessing their relationship with team performance, the relationship between the two predictors quality of communication and shared mental models is discussed. It is certainly crucial for hybrid teams to maintain high-quality communication in order to develop shared

mental models, as postulated by Cannon-Bowers et al. (1995). This relationship is especially important at the beginning of a team's life cycle (Badke & Schaub, 2007) which is in line with the student teams of this study as they have not worked together as a team before the seminar. Later in a team's life cycle, individuals may have increased their knowledge about their team members. Furthermore, the task's requirements may have been communicated and exchanged more, resulting in team members' increased knowledge about the task. Consequently, shared mental models may have reached a higher level in teams that have collaborated for an extended period. Therefore, it is possible that once shared mental models have reached a high level in a team, they may reduce the need for communication as some processes are now implicitly understood between team members (Badke & Schaub, 2007). This is also in line with the bidirectionality of the relationship as postulated by Cohen and Bailey (1997) in their team effectiveness model. Therefore, the relationship between quality of communication and shared mental models in hybrid teams is an important one

6.2 Limitations

Despite its merits, the results must be interpreted with caution. Drawing causal conclusions from a model based on the theoretical foundation of an input-process-output (I-P-O) framework could result in misguided assumptions. Instead of adhering to a purely unidirectional perspective, it is important to consider bidirectional relationships and acknowledge the cyclical nature of team processes. The causality typically assumed by structural equation modeling must be viewed with prudence as well. Normally, causality in structural equation modeling can be expected through the use of longitudinal data (Tarka, 2018). This study has collected data at two points; however, these were not sufficient enough to create a true longitudinal study design. Reports of students who claimed that the first questionnaire was handed out too early to indicate team processes have led to concerns. Consequently, quality of communication, shared mental models, and team performance data have all been drawn from the second survey, and none of the variables could be assessed in terms of their possible change over time. This practically results in a cross-sectional study design, leading to an impossibility of deriving causal interpretations. This issue has been clear prior to derivation of hypotheses which is why they have not been formulated in a causal manner. However, it must still be mentioned and considered when reflecting about interpretation of results.

Furthermore, a cross-sectional study design with self-reports of both independent and dependent variables created an increased possibility for common rater effects and thus, common method bias (Podsakoff et al., 2003). When testing for common method bias, the results provided numerical reasons to neglect this concern throughout analyses. However, common

method bias cannot be ruled out completely. If present, it could have led to inflation of relationships between variables as students may have replied more similarly as external raters did. Moreover, in the external performance ratings provided by the two lecturers, only the influence of communication quality on team performance in TU classes resulted in a significant positive relationship. Therefore, externally rated performance only partially serves as a robustness test, specifically, for the positive relationship between quality of communication and team performance. Differences in the results could origin in the measurement. Team members have assessed their performance process on a multi-item scale while the seminar leaders have reported a single performance output measure. Furthermore, the student sample creates room for the possibility of socially desired responses, due to the upcoming grading or out of respect for their teammates.

Additionally, this study represents a field study which is an accurate way to measure teams, rather than in artificially created laboratory settings. However, it has researched student teams which do not adequately depict an organizational setting and therefore creates a limit in external validity. For example, the descriptive mean values of quality of communication (M = 4.45), shared mental models (M = 4.19), and team performance (M = 4.18) are rather high, considering they have been measured on a 5-point Likert scale. This could be a ceiling effect result. However, it is questionable whether this score accurately reflects a real-world organizational setting. Furthermore, organizational teams mostly work together for longer than a week. Additionally, team members in organizational teams may have more specific expertise than students when tackling a task, leading to different initial conditions of team shared mental models. Hence, generalizability of the results should be taken with great caution.

Moreover, the rather small sample size inhibited a certain level of analytical variability. The method of partial least squares structural equation modeling allows for rather small sample sizes, however, flexibility to directly include control variables into the model or to use covariance-based SEM as analyses method was thus prevented.

Furthermore, influences of other variables cannot be completely ruled out in this study. When analyzing control variables, a possible confounding influence of university, team size, and gender distribution within the teams was tested and found as nonsignificant. However, generally, length of team cooperation can be expected to have an influence on several team processes as team members know each other better and less surprises may be discovered along the way. Therefore, it cannot be completely ruled out that length of cooperation nevertheless had an impact.

Finally, it is possible that the measurement of task interdependence did not adequately depict the construct as positioned in the literature. The relatively similar task may have not allowed for true investigation of the construct. Low indicator loadings have led to exclusion of the construct from the structural model and have made it impossible to make any further derivations about its relationship with any of the other constructs, which is also why it did not make any sense to explore it further via exploratory analyses. This must stay in mind when analyzing the results, especially regarding the I-P-O structure.

6.3 Future Research

In order to meet the cyclic character of the model of team effectiveness by Cohen and Bailey (1997) which has been underlined by Marks et al. (2001), not only longitudinal studies are important, but also periodically, potentially quarterly, surveys. In this study, the timespan of student teams working together was rather short. However, in an organizational setting, teamwork often reaches beyond months or years. During this time, focusing on the cyclic character and the dynamic team process is crucial. Tackling perceived lack of communication quality or a limited overlap of individual mental models early on can prevent further difficulties by intervening early and thus fostering means of strengthening those concepts.

Simultaneously, timing must be chosen carefully to ensure that surveying these team processes does not occur too early either. In the present study, the first survey was handed out at the very beginning of the teamwork, resulting in little possibility for the students to develop shared mental models. Consequently, some students have expressed their inability to report team process feedback in the additional comment section of the first survey. They claimed these questions being asked too early as teamwork had not properly begun. In this study, the issue was resolved by analyzing quality of communication and shared mental models data obtained during the second survey which was handed out at the end of the teamwork. Furthermore, particularly in SFU teams, this was a special case of teamwork compared to most organizational settings as the time of working together was rather short. Thus, the issue can be expected to be naturally compensated in the majority of future team research. However, this must stay in mind of researchers who are planning to survey teams during their teamwork to meet the cyclic character. Furthermore, when creating a longitudinal study, it must be ensured that measuring the same concepts at different points in time allows for comparison, which is one of the strengths of longitudinal studies. In this case, it would not have been possible to report a possible development of quality of communication or shared mental models as the answers given during the first survey most likely were random indications rather than actual reflections. For future studies, it is therefore important to carefully consider the timing of the first survey.

This could involve either allowing a longer period for team collaboration before administering the survey or ensuring that the survey is distributed only after all team members have begun working together. In the context of student teams, the latter can be achieved by requiring them to submit an initial draft of their presentation structure shortly after receiving the task, after which the first survey can be distributed.

Additionally, team research is often faced with a rich variety of concepts with various possible relationships. It would have gone beyond the scope of this thesis to include and analyze all of them. Nevertheless, in future studies, different concepts of hybrid teamwork should be addressed. Simultaneously, the constant challenge to fulfill requirements of all concepts which could possibly have an influence should remain at the forefront of any researcher's mind when delving into the complex world of hybrid team research. To remain within the I-P-O framework, the three components of team effectiveness outlined in Cohen and Bailey's (1997) model offer comprehensive opportunities for further research. While this study has focused on performance outcomes as the first component, attitudinal outcomes such as job satisfaction as the second, and behavioral outcomes such as turnover absenteeism as the third present valuable avenues for future studies applying a similar model. Moreover, the present study has placed limited emphasis on the concept of team collaboration. However, exploratory findings about a lower level of variance within the team being related to a higher level of team performance provide reason to further assess team collaboration in hybrid team research.

Furthermore, future research should consider potential indirect effects. This study has focused on direct effects between variables which simplifies the model and allows for the testing of straightforward hypotheses. However, future research may find deeper mechanisms through indirect relationships that could provide valuable insights into how certain variables influence team performance.

The design of task interdependence should also be picked up in further studies. It is relatively unclear why its measurement did not function as expected in the present study, but one possible explanation is the rather similar task design. Consequently, future studies who measure task interdependence should focus on task design while ensuring different levels of interdependence.

Concretely, the following key points deserve emphasis to facilitate the design of a similar structural equation modeling study that allows for causal inferences. First, if generalizability within the organizational context is desired, organizational teams rather than student teams should be chosen as the sample. Second, a larger sample size would increase model stability and flexibility. Third, it would be beneficial to either conduct additional survey rounds or ensure

that the initial survey is handed out after teams have had enough time to work together, enabling them to meaningfully report their perceived level of communication quality and shared mental models. Fourth, it is important to maintain teams within the size range of three to five members. In cases of dropouts, these should be thoroughly documented and reported. Fifth, all teams should ideally have the same length of cooperation, preferably spanning at least several weeks, to ensure consistency across the study. Sixth, the task should be structured to encourage regular team meetings. Lastly, performance should be assessed externally using a validated scale rather than a single item to ensure inclusion in a structural equation model, and furthermore a reliable and valid measurement of team performance.

6.4 Practical Implications

Based on the results, decision-makers should foster quality of team communication and shared mental models in hybrid teams as they both have a positive association with team performance. Specifically, quality of communication should be assessed early in a team's life cycle. This creates the chance to address possible difficulties before a low level of quality of communication may inhibit the formation of shared mental models. Similarly, development of both team and task shared mental models should be promoted and included in the team's communication. Regular surveys increase the possibility to detect changes over time. Moreover, when analyzing the results, the current point of a team's life cycle must be considered as well. Teams who have just started working together versus teams who have reached a later point of their collaboration may score different results. They may need different support concerning their implementation of increased communication quality and their development of shared mental models. However, by addressing lack of communication quality early, the possibility for improvement of all three – quality of communication, shared mental models, and team performance – arises. Through a high level of communication quality from the start, both a quicker development of shared mental models and an enhanced team performance can be achieved in a best-case scenario.

6.5 Conclusion

This study has started to dive into the seemingly endless world of hybrid team research. While the role of task interdependence remains unclear and requires further research, quality of team communication could be positively associated with team performance, and, despite certain methodological and conceptual limitations, can still be considered to take on a crucial role in this relationship. Similarly, shared mental models, both about the team and the task, have equally shown a positive association with team performance. The desire to create an overlap of

each team member's individual mental models as well as a high level of communication quality must therefore be kept high in hybrid teams.

In future research, the hybrid team's cyclic and dynamic character should be considered, resulting in regular surveys to allow effective planning of impactful interventions. While a causal approach with an organizational sample can be considered as the next theoretical step, the study nevertheless practically suggests a focus on both quality of communication and shared mental models in hybrid teams. Meanwhile, their influence must be understood within the broader context, recognizing the role of other contributing factors. By including other possible underlying factors, future hybrid team researchers must acknowledge that their research field is as dynamic as the team structure itself. Equally, decision-makers in organizations should not only consider multiple contributing factors but also the dynamic of a team's life cycle in order to maximize the potential for enhancing hybrid team performance. As hybrid teams represent both the present and the future of modern organizational collaboration, this should inspire researchers to revisit well-established concepts from the face-to-face team literature and adapt them to the context of hybrid team research structure.

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10 List of Abbreviations

AI	Artificial Intelligence
AVE	Average Variance Extracted
ICT	Information Communication Technology
I-P-O	Input-Process-Output
SMM	Shared Mental Models
PLS-SEM	Partial Least Squares Structural Equation Modeling
VIF	Variance Inflation Factor

11 Abstract (English)

Despite their growing prevalence, research on hybrid teams which combine remote and in-person work remains limited. This thesis examines the relationships between task interdependence, quality of communication, shared mental models, and team performance in hybrid teams. Drawing on team communication and shared mental model theories while supported by the input-process-output (I-P-O) framework, this study aims to deepen understanding of hybrid team dynamics. Data were collected from 536 students in 127 teams across six university classes, who completed a collaborative task under hybrid conditions. The final sample size included 113 teams. Key constructs were measured using validated scales, and hypotheses were tested through partial least squares structural equation modeling. Results show significant positive associations between both quality of communication and shared mental models with team performance, as well as between quality of communication and shared mental models. However, no relationship could be examined between task interdependence and either quality of communication or shared mental models. Limitations include possible common method bias from self-reports, the lack of longitudinal data inhibiting causal inferences, and the student sample reducing generalizability of the results to organizational settings. This study highlights the importance of communication quality and shared mental models in enhancing hybrid team performance. Practical implications include fostering communication quality and shared mental models strategies early within hybrid teams' life cycles. Future research should expand sample size, employ longitudinal designs, and investigate hybrid teams in organizational contexts.

Keywords: hybrid teams, task interdependence, quality of communication, shared mental models, team performance

12 Abstract (German)

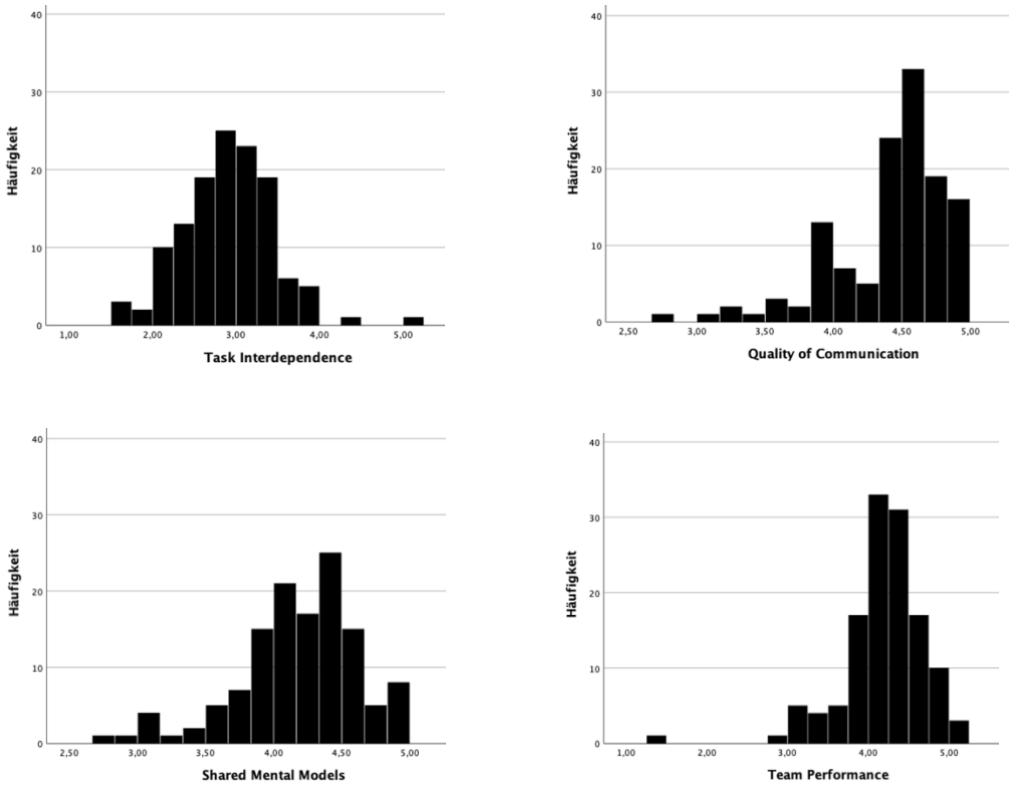
Hybride Teams kombinieren Online- und Präsenzzusammenarbeit und weisen eine zunehmende Verbreitung auf. Nichtsdestotrotz ist die Forschung zu hybriden Teams bisher limitiert. In dieser Arbeit werden die Beziehungen zwischen der Interdependenz von Aufgaben, der Qualität der Kommunikation, der geteilten mentalen Modelle und der Teamperformance in hybriden Teams untersucht. Die vorliegende Studie stützt sich auf Theorien zur Teamkommunikation und zu geteilten mentalen Modellen, die durch das Input-Prozess-Output-Modell (I-P-O) ergänzt werden, und zielt darauf ab, das Verständnis der Dynamik hybrider Teams zu vertiefen. Es wurden Daten von 536 Studierenden in 127 Teams verteilt auf sechs verschiedene Universitätsseminare erhoben, die eine Teamaufgabe unter hybriden Bedingungen durchgeführt haben. Die finale Stichprobengröße bestand aus 113 Teams. Konstrukte wurden anhand validierter Skalen gemessen und die Hypothesen durch Partial-Least-Squares-Strukturgleichungsmodellierung getestet. Die Ergebnisse zeigen signifikante positive Assoziationen zwischen der Qualität der Kommunikation und Teamperformance, zwischen geteilten mentalen Modellen und Teamperformance, sowie zwischen der Qualität der Kommunikation und geteilten mentalen Modellen. Es konnte jedoch kein Zusammenhang zwischen der Interdependenz der Aufgaben und der Qualität der Kommunikation oder geteilter mentaler Modelle getestet werden. Zu den Einschränkungen gehören mögliche Verzerrungen durch Selbstberichte, die Hemmung kausaler Schlussfolgerungen durch das Fehlen von Längsschnittdaten, und die aus Studierenden bestehende Stichprobe, die eine Generalisierung der Ergebnisse auf Organisationen einschränkt. Die Studie unterstreicht die Bedeutung der Qualität der Kommunikation und der geteilten mentalen Modelle für die Verbesserung der Performance hybrider Teams. Zu den praktischen Implikationen gehört die Förderung der Qualität der Kommunikation und der Strategien für geteilte mentale Modelle zu einem frühen Zeitpunkt in der Zusammenarbeit von hybriden Teams. Zukünftige Forschung sollte den Stichprobenumfang vergrößern, Längsschnittdesigns verwenden und hybride Teams in organisationalen Kontexten untersuchen.

Schlagwörter: Hybride Teams, Aufgabeninterdependenz, Qualität der Kommunikation, geteilte mentale Modelle, Teamperformance

13 Appendix A

Figure A1

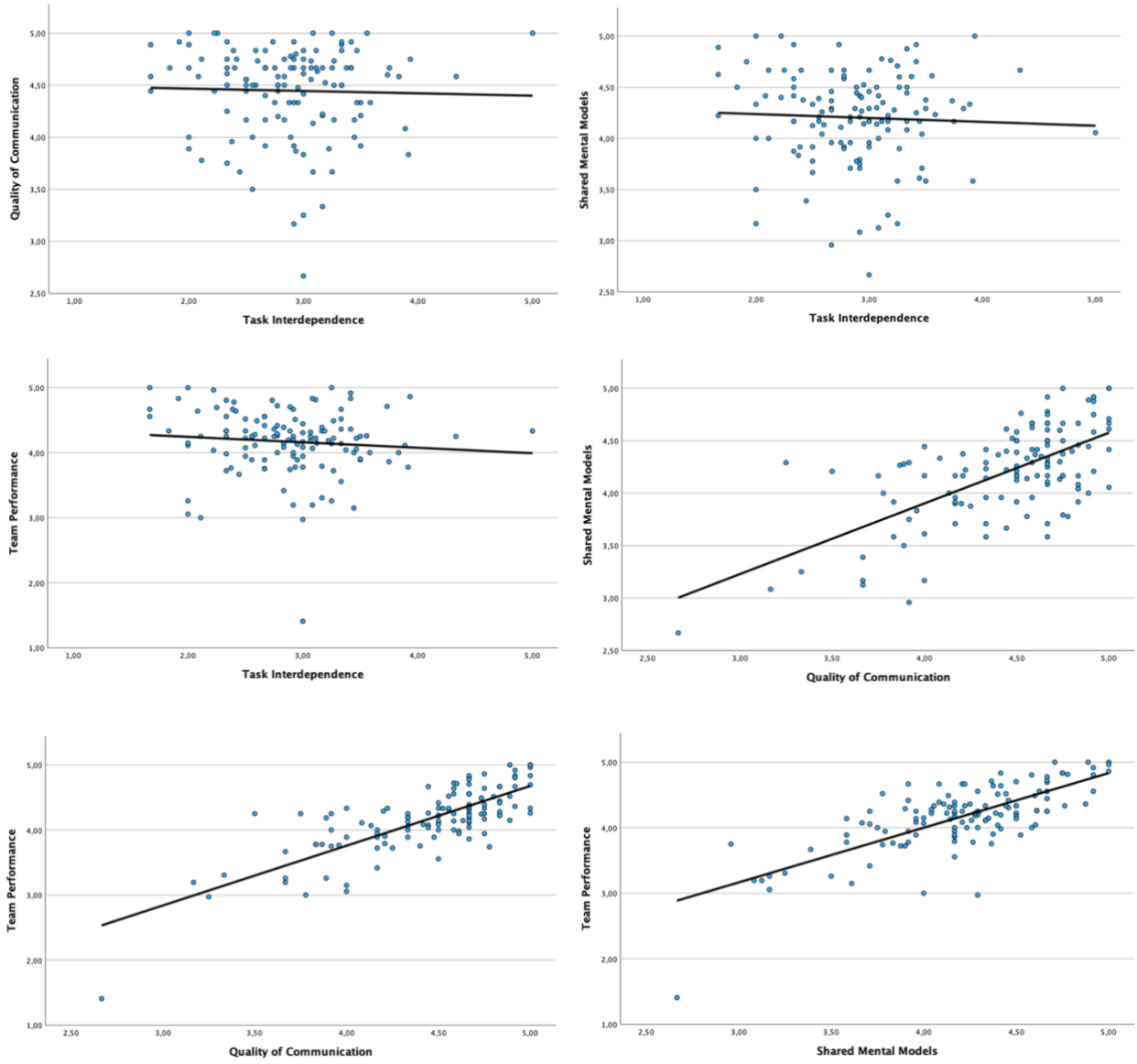
Histograms of the Distribution of the Latent Constructs



14 Appendix B

Figure B1

Bivariate Scatterplots



15 Appendix C

15.1 JASP Syntaxes for Partial Least Squares Structural Equation Modeling

15.1.1 Original Model: With INT

#measurement model

TaskInterdependence =~ INT1 + INT2 + INT3

QualityOfCommunication =~ QCOMM1 + QCOMM2 + QCOMM3

SharedMentalModels =~ teamSMM1 + teamSMM2 + teamSMM3 + taskSMM1 + taskSMM2 + taskSMM3

TeamPerformance =~ PERF1 + PERF2 + PERF3 + PERF4 + PERF5 + PERF6 + PERF7 + PERF8 + PERF9

#structural model

QualityOfCommunication ~ TaskInterdependence

SharedMentalModels ~ TaskInterdependence + QualityOfCommunication

TeamPerformance ~ QualityOfCommunication + SharedMentalModels

15.1.2 Adjusted Model: Without INT

#measurement model

QualityOfCommunication =~ QCOMM1 + QCOMM2 + QCOMM3

SharedMentalModels =~ teamSMM1 + teamSMM2 + teamSMM3 + taskSMM1 + taskSMM2 + taskSMM3

TeamPerformance =~ PERF1 + PERF2 + PERF3 + PERF4 + PERF5 + PERF6 + PERF7 + PERF8 + PERF9

#structural model

SharedMentalModels ~ QualityOfCommunication

TeamPerformance ~ QualityOfCommunication + SharedMentalModels

Note that syntax 15.1.1 and syntax 15.1.2 should be inserted in two different repetitions of the respective *Model 1* section of JASP's *Partial Least Squares SEM* under *Structural Equation Modeling*. Do not change any settings at the *Model* section. At the *Estimation* section, choose *Bootstrap* with 5000 bootstrap samples under *Error calculation method*. Choose *R-squared*, *Additional fit measures*, *Reliability measures*, and *Observed construct correlations* at the *Output* section. Finally, choose *Predict endogenous indicator scores* and *Linear model* at the *Prediction* section.