Factors Affecting Team Dynamics, Performance, and Creativity

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Thesis submitted in partial fulfilment for the degree of Doctor of Philosophy

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Abstract

Teamwork, creativity, and innovation are essential 21st-century skills as team collaborations become organisations' default strategies to innovate optimal solutions to complex problems. Previous research established effects between a team's dynamics on their performance and creativity; however, contradictory results highlight the need for further research and investigation. A key issue is the 'poverty of the outcome measure', with most studies limited to post-session questionnaire data. A key feature of the studies reported here was the live coding of all verbal interactions using a newly developed iPad app to implement Rackham's Behaviour in Teams (BiT) coding to measure a team's dynamics.

The Covid-19 pandemic also revealed important questions unanswerable by currently available literature regarding the differences between face-to-face (F2F) team collaborations and online team collaborations on video conferencing platforms (e.g., Teams/Zoom). In four experimental studies, this PhD used the BiT app to create rich, sequential data on the teams' interactions as they undertook short and lengthy tests of teamwork and creativity. It also evaluated the effectiveness of providing teams feedback about their communication patterns in subsequent tasks. All four studies were undertaken with teams of undergraduate Psychology students.

Study 1 was a pilot investigating the BiT coding app's ability to precisely code a team's verbal interactions during idea generation & creativity problem-solving (innovation) tasks and effectiveness in providing feedback about their dynamics. Improved idea generation was associated with more balanced participation equity rates (PER) and significantly correlated with increased team total interaction frequencies (TIF). Teams receiving feedback also had increased TIF and better PER in subsequent tasks.

Study 2 integrated the recommendations of study 1and replicated it using the 15-category BiT coding system. The Covid-19 pandemic and subsequent lockdowns forced data collection to

be halted halfway. Analyses of the collated data found that increased team total interaction frequencies negatively affected their idea generation, contradicting study 1's findings. However, the data also indicated significant relationships between a team's TIF and PER in the team's innovative performance.

Study 3 was an experimental study investigating team dynamics and idea generation performance differences between F2F and online teams. The results indicated no significant differences between F2F and online teams on idea generation performance and total verbal behaviour frequencies. Results found that online teams with Cameras off had significantly better participation equity than F2F teams and online teams with Cameras on.

Study 4 replicated Study 2 virtually to understand virtual team dynamics during idea generation and creative problem-solving tasks and evaluate the effectiveness of providing feedback improves virtual team dynamics and performance. The results indicated findings from the previous studies were supported and that providing feedback helped improve team dynamics, idea generation, and creative problem-solving performance, especially in underperforming teams.

The original contributions to knowledge from this PhD are fourfold. First, insights were obtained about using the newly developed and technologically aided BiT coding iPad app to precisely live-code a team's dynamics and use its detailed analyses to provide effective short-cycle feedback. Second, further insights were obtained regarding the relationships and trends between team dynamics and their creativity and innovation. Third, new insights about the effects of virtuality on team dynamics, the type of information exchanged and effectiveness during collaborations were obtained. Lastly, recommendations are made for practitioners, researchers and institutes of higher education and organisations seeking to teach or enhance team dynamics, performance and creativity.

Keywords: creativity, innovation, team performance, live verbal behaviour coding, online team collaboration, face-to-face team collaboration, participation equity, team dynamics

Acknowledgements

The long and arduous journey of completing this PhD would have been impossible without several people's constant input and support. First, I would like to thank my supervisors: Prof. Rod Nicolson and Prof. Simon Bolton.

Rod, I am grateful for your constant input and reminders to be proud of my work, power through the unknown, and not sweat the small stuff. Simon, thank you so much for highlighting the importance of relaxing and finding the gold nuggets within the swaths of pebbles (data). I am blessed to have your support and be taught many life lessons.

I next would like to show my gratitude to the participants, students and staff at Edge Hill and Cardiff University for their contribution towards the data collection for each chapter. Without your support, the thesis would have never been completed.

To my dearest Angel, thank you for the patience and moral support provided, especially when feeling down and lost. It has not been easy for you to see me at my lowest moments, but your unwavering trust in me and my abilities helped keep me moving. I am uncertain about what I will face in the future, but I am sure you will be there to motivate, support and celebrate successes together.

Saving the most significant bits for my family: To my sisters, Sharlene and Charlotte, it has been a long 8 + years since I first left to study overseas; thank you for filling up the void created by my departure. It’s time for both of you to pursue your goals too. To my parents, thank you so much for supporting all my life endeavours. It has been a long wait for this very moment, and I know not much praise will be given to “keep me grounded”, but I hope you are proud that this chapter has been completed.

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Overview Of The Thesis

Teamwork, creativity, and innovation are essential 21st-century skills as team collaborations become organisations' default strategies to innovate optimal solutions to complex problems. Contradictory previous findings, lack of accurate measures, effective interventions and literature investigating the differences between face-to-face (F2F) and virtual team collaborations complicate adopting and teaching ‘good practice guidelines’, highlighting the need for further research and investigation. This PhD evaluated the feasibility of using verbal behaviour analysis via the Behaviour in Teams (BiT) coding iPad app to measure a team’s dynamics and answer different research questions. It also assessed the effectiveness of providing teams feedback about their communication patterns in subsequent tasks. The following sections provide a broad overview of the methodology and findings for each empirical study chapter.

Chapter 1 briefly overviews the currently identified challenges in understanding good team dynamics and their relationship with the team’s effectiveness. It also introduces the differences between teams and groups, the use of behaviour analysis to measure team dynamics, and the impacts of COVID-19 on team interactions.

Chapter 2 provides a broad review of the literature surrounding team creativity and innovation and their relationships with team dynamics. It also reviews the literature regarding the effects of virtuality on these relationships and the effectiveness of providing feedback to teams to improve future team dynamics and performance.

Chapter 3 explores the methodological approaches and tasks adopted in the research project of this PhD. It also describes how the BiT coding system can help obtain insights about team dynamics and be used to improve team dynamics.

Chapter 4 details a pilot study testing the effectiveness of providing team dynamics feedback to modify subsequent team dynamics and task performance. The study utilised a simplified version of the BiT coding app to live-code team dynamics and provided the data necessary to provide said team dynamics feedback. This study provided a framework and recommendations for the subsequent empirical study.

Chapter 5 extends the findings from Chapter 4 by incorporating its recommendations and using the 15-category BiT coding system to measure a team's dynamics during idea generation and creative problem-solving tasks. It also evaluated the effectiveness of providing team dynamics feedback to modify subsequent team dynamics and task performance. Recordings and transcripts of the teams were made to obtain insights about the content, context, and sequence of verbal behaviours potentially related to team creativity and innovation. The results suggest that the task context could see relationships between team dynamics and task performance to differ.

Chapter 6 builds upon the second study's findings and investigates the effects of virtuality and camera usage on a team's dynamics and creativity. It also examined whether the relationships between a team's dynamics and idea generation performance would differ based on virtuality. Thirty-two teams were randomly allocated to three experimental groups: 1) Face to face, 2) Virtual (Cameras on) and 3) Virtual (Cameras off) and completed the Guilford Alternative Uses Task used in the previous studies. The findings suggest that the relationships between a team's dynamics and idea generation performance would differ based on virtuality and that the quality of interactions could explain this difference. The study also provides evidence that live verbal behaviour coding of teams in a virtual setting using the BiT coding app is feasible.

Chapter 7 broadens the previous study's findings and investigates the relationship between team dynamics, creativity, and innovation for 34 virtual teams with cameras on. It also

evaluated the effectiveness of providing virtual teams feedback on their subsequent team dynamics and performance during subsequent iterations of the experimental tasks. The study utilised a virtualised adaption of Study 2's methodology and investigated team dynamics using creativity and creative problem-solving tasks. The study also compared participants' team dynamics and task performance when they were allocated to either the control or feedback condition. The findings suggest that the team's dynamics and relationships with their performance differ across tasks, and feedback effectively improved a team's dynamics and performance. It also provides further evidence of the feasibility of utilising the BiT coding app to conduct live verbal behaviour coding and give virtual teams feedback as an intervention to improve their dynamics and performance.

Chapter 8 provides a general overview of the empirical studies and findings. This chapter also provided insights and things to consider when using the BiT coding system and live verbal behaviour coding. The directions for future research, limitations, and the broader application of the findings are also discussed.

Chapter 1 Background and Introduction

Essential 21st-century skills

In today's 21st-century business climate, technological advances and globalisation have resulted in a complex 21st-century workplace where organisations and businesses can quickly expand into other countries and across continents, making markets truly global (Mead & Andrews, 2009; Saavedra & Opfer, 2012). This has required organisations to adapt and find new ways to stay ahead of the competition in this everchanging complex environment through team collaborations and the integration of information technology (Choi & Chang, 2009).

Organisations view effective team collaboration as a crucial success factor towards the innovation and creation of novel optimal solutions to answer the complex 21st-century problems they face (Bear & Wolley, 2011; Klug & Bagrow, 2016; Van Der Zee et al., 2004; Wuchty et al., 2007). As such, individuals joining the workforce are expected to be proficient with additional 21st-century applied skills and competencies (Table 1-1) other than the subject knowledge learnt through the educational system (Casner-Lotto & Barrington, 2006; Dede, 2009; Levy & Murnane, 2005; Saavedra & Opfer, 2012). These skills include teamwork/collaboration, oral communication, creativity/innovation, and critical thinking/problem solving (Buhler & White, 2007; Levy & Murnane, 2005; Silva, 2009; Vik, 2001).

Table 1-1- Basic and applied skills essential to 21st-century organisational success (Casner-Lotto & Barrington, 2006).

Basic Skills	Applied Skills
English language (spoken)	Critical thinking/Problem solving
Reading comprehension (in English)	Teamwork/Collaboration
Writing in English	Creativity/Innovation
Mathematics	Diversity
Science	Oral communications

Government/Economics	Written communications
Humanities/Arts	Leadership
Foreign languages	Information technology application
History/Geography	Lifelong learning/Self-direction
	Professionalism/Work ethic
	Ethics/Social responsibility

To better prepare their students for the workforce, universities attempted to develop these skills in their students through compulsory team collaboration projects (Silva, 2009; Vik, 2001). However, employers and organisations have commented new employees to the workforce still lack proficiency in the abovementioned skills, especially in teamwork, oral communication, creativity and critical thinking/problem-solving (Buhler & White, 2007). This highlights the importance of obtaining further insights into the factors affecting team effectiveness, creativity, and innovation.

Team Effectiveness

The capacity for teams to succeed or fail in their objectives is termed 'team effectiveness' (Aubé & Rousseau, 2011). Team effectiveness is the team's capacity to accomplish goals given by authorised personnel or organisations (Aubé & Rousseau, 2011). Many factors and aspects are synonymous with team effectiveness, such as team problem-solving, creativity, and overall performance (Aubé & Rousseau, 2011; Halvorsen, 2013; Kozlowski & Ilgen, 2006). For the purpose and context of this PhD, team effectiveness is defined and measured by the team's idea generation and problem-solving performance and its components, which will be discussed in the literature review (see chapter 2).

Factors associated with team effectiveness are widely researched subjects due to their potential financial and performance implications for organisations (Aubé & Rousseau, 2011; Halvorsen, 2013; Kozlowski & Ilgen, 2006), with team dynamics identified as a crucial and instrumental

factor dictating the effectiveness of team collaborations (Johnson, Heimann & O'Neill, 2000; Warner, Bowers & Dixon, 2012). Despite this, there is very little attention paid towards the role of a team's dynamics in the creative innovation process and the various factors affecting the team's ability to generate and implement innovative and novel ideas (Hulsheger et al., 2009; Maier et al., 2015; Somech & Zahavy, 2013). However, it is essential to understand that these research findings mentioned above and in the literature review (in chapter 2) mainly apply to teams and not groups, which makes it necessary to understand the differences between teams and groups and how teams are defined within the context of this PhD.

What are teams?

There is often confusion about the differences between groups and teams because individuals and organisations use the term "teams" arbitrarily and interchangeably without distinguishing between a team and a group. Groups are collectives of individuals that can practice elements of teamwork but do not fulfil the criteria of a team (Lyubovnikova et al., 2015). Some examples of the elements of teamwork are listening, providing constructive responses, providing support, acknowledging achievements, and recognising the interests of other members (Katzenbach & Smith, 1993). It is important to note that these elements of teamwork can work for any collection of individuals, such as groups, departments, or even the entire organisation. Still, they are not enough to be defined as a team.

A large amount of research about teamwork over the recent decades has resulted in multiple definitions in the literature regarding the definition of a team (Hollenback et al., 2012). Sifting through the literature identified some common characteristics of a team not limited to: having common goals and identities, shared responsibility and common approaches, and interdependence (Hollenback et al., 2012).

The first characteristic mentioned above, shared goals, are crucial for teams as they provide a clear direction for members to follow and complete tasks. The direction is typically guided

by the expected outcomes of the assigned task but also flexible enough for constant revisions and adjustments by the team members to give energy and meaning to successfully complete task objectives (Lyubovnikova et al., 2015).

Apart from having common goals and identities, teams will develop a common approach, typically formulated using the mutual understanding of the members' strengths and weaknesses. This allows for better task distributions and regulation of team members' actions when working on the given task (Katzenbach & Smith, 1993). Having a common approach within a team will also help increase the commitment and trust among team members, which increases feelings of shared responsibility towards the given task, reflecting the second characteristic of a team (Katzenbach & Smith, 1993; Kozlowski & Bell, 2012).

Typically, teams work in a larger social setting and system (e.g., organisation, university, faculty) that has set boundaries as determined by various components of the social system the team is situated in, such as the structure, culture, and technology, which will affect how members interact within the team and towards external entities (Kozlowski & Bell, 2012). The boundaries can also be determined by the tasks and responsibilities given to the teams. For instance, a student team completing a module team-based assignment in a university setting will typically only interact with their lecturers and fellow students. However, a team of interdepartmental researchers working on a project in the same university might only interact with other stakeholders involved, reflecting the interdependent characteristics of a team.

The ever-changing and innovation-driven business climate of the 21st century has seen organisations adopt different strategies of utilising teams to optimise productivity, creativity, and innovation. (Bear & Wolley, 2011; Wuchty et al., 2007). Previous research has identified that focused and highly interactive teams are essential for successful innovation within organisations (Fay et al., 2015; Klug & Bagrow, 2016). However, the competitive drive to

stay ahead of rivals through implementing innovative and creative ideas has resulted in teams being created, modified, and disbanded way quicker than ever (Edmondson, 2018).

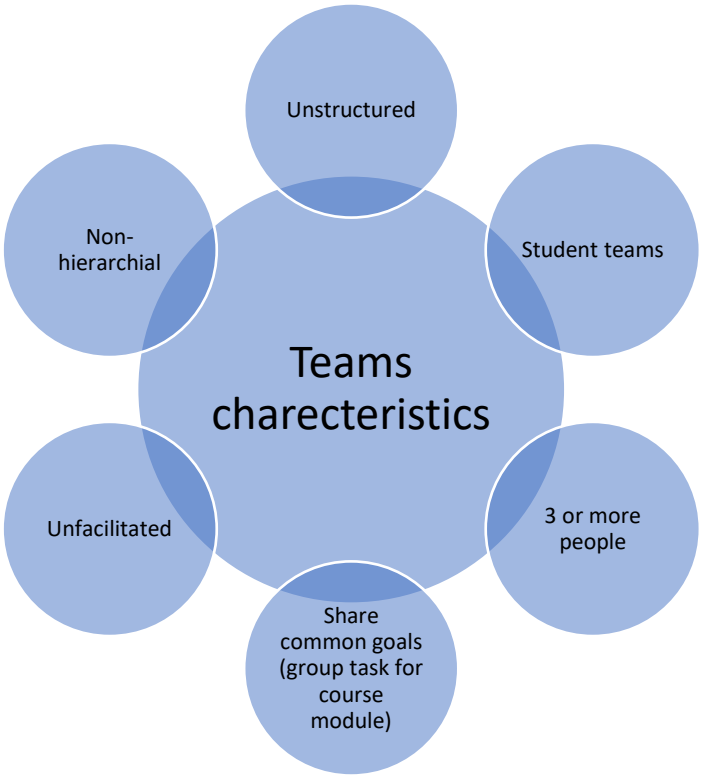


Figure 1-1. Main Characteristics of the teams used in the empirical research conducted in this PhD.

This has resulted in scholars arguing for an update to the definitions of teams, which places more emphasis on the context and approaches to teamwork by the organisation the team originates from (Murase et al., 2012). There are also calls for more focus and research to better understand the underlying processes of effective teamwork in specific contexts (i.e., creativity, innovation, idea evaluation, and action reviews) instead of a one size fits all approach (Marlow et al., 2018; Murase et al., 2012). With all these factors considered, it will be prudent and beneficial to use a simple and flexible definition of teams within the context of this research thesis which is “a group of individuals with social interactions amongst each other while

completing tasks to achieve a mutually shared goal" (West, 2012). The characteristics of the teams utilised in the current research thesis are shown in Figure 1-1 above.

Why work and collaborate in teams?

It is estimated that around three out of four organisations within the UK utilise both long- and short-term team collaborations in their everyday operations to achieve different objectives such as innovation, company growth, and market surveys, which are highly important and related to survival and obtaining a competitive edge over rivals (Aubé & Rousseau, 2011; Bear & Wolley, 2011; Klug & Bagrow, 2016; Van Der Zee et al., 2004; Wuchty et al., 2007).

The most prominent benefit of using a team-based approach is increased creative problem-solving and innovation, allowing optimal and immediate adaptation to ever-changing market environments (Edmonson, 2018; Kozlowski & Bell, 2012). Organisations also view teams as crucial instruments to obtain competitive advantages and catalysts for promoting individual behavioural change and learning, all significantly impacting organisational effectiveness and development (Edmonson, 2018; Kozlowski & Bell, 2012).

There are also positive psychological effects of being part of a team, such as decreased stress levels and work pressure through the socialisation and interactions between team members (Katzenbach & Smith, 1993; Kozlowski & Bell, 2012). The reduced pressure and stress help increase the feelings of fun and self-esteem of the team members, resulting in higher team satisfaction and adaption to the organisational environment (Edmonson, 2018). This has led to teamwork being touted as vital and indispensable for organisations to innovate and thrive in the 21st-century market as it could bring improved productivity, idea generation, and creative problem-solving performances (Edmonson, 2018; Hulsheger et al., 2009; Maier et al., 2015; Richter et al., 2011).

While many studies have promoted the benefits of teamwork, some researchers and studies argue that working in teams and adopting the common characteristics of teams alone does not

provide the benefits claimed above and could also be counterproductive (Bui et al., 2019; Marlow et al., 2018). Further studies have highlighted that communication issues amongst team members, if unidentified and unchecked, could be a potential pitfall that could cost organisations significant resources and time to resolve (Bui et al., 2019; Marlow et al., 2018). The literature suggests that high-quality team meetings could encourage more communication and information exchange whilst preventing or mitigating the negative aspects of team working (Bui et al., 2019; Marlow et al., 2018; West, 2012). As such, it is essential to understand the factors affecting effective and high-quality team meetings to allow organisations to reap the benefits of teamwork that drive productivity and innovation.

Team meetings are used in organisations for various purposes (brain storming, information sharing, problem-solving, idea generation etc.), and organisation employees could spend 17 hours a week on average participating in meetings (Cohen et al., 2011). However, 50% of organisation employees found their meetings a waste of time and unproductive meetings costing organisations in America an estimated 37 billion dollars annually (Cohen et al., 2011; Romano & Nunamaker, 2001).

The high monetary and time costs of unproductive meetings highlight the importance of effective and high-quality meetings, which can significantly improve an organisation's productivity, creativity, innovation, and morale (Cohen et al., 2011; Gabelica et al., 2014a, 2014b; Johnson et al., 2013; Kaufield & Lehmann-Willenbrock, 2012). Although previous research identified multiple factors associated with effective and high-quality team meetings, team dynamics is considered one of the most important due to their inseparability from the team's rate of information exchange and effectiveness (Li et al., 2018).

Using Behaviour Analysis to understand and improve a team's dynamics

Team dynamics is defined as the social interaction, systems of behaviours, and psychological processes of the members within a team (Johnson et al., 2000; Warner et al., 2012). Teams with

better group dynamics can communicate better, exchange more information (Li et al., 2018), and be more cohesive, productive, creative and successful (Warner et al., 2012; Zoltan, 2015). Therefore, it is no surprise that there is extensive research on factors affecting team dynamics to formulate best practices for organisations and interventions to improve it (Aubé & Rousseau, 2011; Halvorsen, 2013; Kozlowski & Ilgen, 2006).

One of the suggested interventions is to provide teams feedback about their team's dynamics to improve their dynamics during subsequent sessions. Previous research has shown feedback to be effective in improving team dynamics, performance and creativity (Gabelica et al., 2014a, 2014b; Johnson et al., 2013) as it allows for increased team learning through reflection that subsequently improves future team dynamics, performance and creativity (Gabelica et al., 2012). However, the effectiveness of the given feedback is underpinned by the quality and quantity of the information it is derived from (Farley et al., 2018). A method to obtain accurate, detailed summaries of the team's dynamics required for effective feedback is behaviour analysis which utilises non-intrusive observations and behaviour coding schemes to code and quantify behaviours occurring during the team's interactions (Brauner et al., 2018).

Various coding schemes and systems have been developed to measure various aspects of a team's dynamics and interactions, such as the Interaction Process Analysis method (IPA), Behaviour Analysis Coding System (BACS), Act4teams coding scheme, and CoCo coding coherence system (Brauner et al., 2018). However, most of these schemes and systems required coders to use retrospective coding and analysis of audio-video recordings or contained too many categories to be used during live real-time coding sessions (Brauner et al., 2018). The lack of live real-time coding systems sees delays in providing feedback to teams that may reduce the effectiveness of the given feedback (Farley et al., 2018; Thornock, 2016).

Technological advances have allowed the development of portable computers and tablets, which in turn saw the development of mobile applications that could facilitate the use and adoption of live verbal behaviour coding. The newly developed 15-category Behaviour in Teams (BiT) coding iPad app is a variation of the Behaviour Analysis Coding System (BACS) that allows coders the ability to live code a team's verbal behaviours and provide instantaneous feedback about their dynamics (Farley et al., 2018). To the researcher's knowledge, little to no research has been conducted to investigate the feasibility of live real-time verbal behavioural coding of a team's dynamics and the effectiveness of using its data summaries to provide feedback to teams. As such, there are many unknowns of a technical and logistical nature surrounding the efficacy of live real-time behavioural coding of a team's interactions and using its data summaries to provide feedback (Brauner et al., 2018).

Covid-19 and associated challenges

In March 2020, the World Health Organisation declared the outbreak of the infectious respiratory disease Coronavirus (COVID-19) as a global pandemic (WHO, 2020). Following this, "Stay at Home" lockdown measures were put in place in the UK and globally to avoid the rapid transmission of this deadly virus. These developments led to suspending many face-to-face (F2F) activities in organisations and Higher Education (HE) institutions, including the empirical studies originally planned for this PhD.

During the Covid-19 pandemic and associated lockdowns, organisations adopted virtual video collaborations as the primary method to maintain organisational productivity (Brenan, 2020). A seamless transition from F2F to virtual collaborations was expected, allowing organisational productivity to be maintained at pre-pandemic lockdown levels. However, reports have revealed organisations and practitioners struggle to achieve effective virtual team collaboration with good practice guidelines established for F2F teams (Fosslien & Duffy, 2020; Jiang, 2020; Wiederhold, 2020).

There have also been reports of specific phenomena and issues related to online team collaborations, such as Zoom fatigue, background environmental distractions etc. (Fosslien & Duffy, 2020; Jiang, 2020; Moses, 2020). These phenomena have been found to negatively affect the team dynamics and interactions of online team meetings and collaborations (DeFilippis et al., 2020; Wiederhold, 2020). Some recommendations to combat them suggest individuals keep their Cameras off during sessions to combat and reduce Zoom fatigue, environmental distractions, and other factors (Wiederhold, 2020). However, this suggestion contradicts recommendations for online team meetings to be conducted with Cameras on to enhance team effectiveness and productivity (Tasir & Al-Dheleai, 2019).

Given these developments and contradictory recommendations, it resulted in important questions being asked: 1) What are the differences between the team dynamics of F2F and virtual team collaborations? and 2) Does camera usage impact the effectiveness of virtual team collaborations?

Research Questions

This PhD focused on obtaining further insights into the factors affecting a team's creative and innovative performance. Specifically, the PhD aimed to understand how 1) Team dynamics and verbal behaviours, 2) Providing team dynamics profile feedback, and 3) Different interaction medium platforms (F2F, Camera on and Camera off) might impact a team's creativity and innovation performance. The BiT coding system was used to live code and quantify the verbal interactions made by the participant teams when completing their experimental study session tasks. Quantitative and qualitative approaches were then used to explore the different factors related to a team's dynamics on their creative and innovative performance outcomes. Using these methods, the PhD aimed to address the following theoretical research questions:

RQ1: How do a team's dynamics affects its creativity and innovation?

RQ2: What verbal behaviours affect a team's creativity and innovation?

RQ3: What are the differences in team dynamics, creativity, and innovative performance between F2F and online teams?

RQ4: Does camera usage impact the dynamics and performance of online team collaborations?

RQ5: Does immediate communication profile feedback improve future team dynamics and creative and innovative task performance?

Addressing these research questions would help update currently available guidelines about effective F2F team collaboration guidelines. It will also help understand and educate the differences between F2F and online team collaborations. This can subsequently aid in establishing good practice guidelines for new online team collaboration, especially within team creativity and innovation contexts. Utilising the BiT coding system and iPad app within the empirical studies of this PhD would also contribute more insights into the technical and logistical requirements of incorporating live verbal behavioural coding within a research design. It would also help evaluate the feasibility of live verbal behavioural coding and the effectiveness of using its data summaries to provide teams feedback to improve their team's interactions and dynamics.

Chapter 2 Literature review

This chapter provides a broad overview of the current literature regarding the relationships between team dynamics on team creativity & innovation, how virtuality could impact team dynamics and performance, and whether providing teams feedback could improve their subsequent task dynamics and performance.

The first section of this chapter explores the literature on team creativity and innovation. It is followed by reviewing the relationships between team dynamics on creativity and innovation. The following section explores the existing literature regarding the effects of virtuality on a team's dynamics and creative/innovative performance. The last section of the literature review examines the effectiveness of providing feedback to teams and how verbal behavioural coding could be used to improve team dynamics and performance.

Team creativity and innovation

As mentioned, the ability for teams to think creatively and be innovative is highly valued in organisations as it allows for better problem-solving performance that sees the creation and adoption of high-quality, original and elegant solutions to problems faced (Harvey, 2013; Mumford et al., 2012). However, there have also been confusion and misunderstandings of the concepts and relationships between creativity and innovation (West, 2012), with scholars calling for clear differentiation between the two to reduce confusion (Eisenbiss et al., 2008; Hulsheger et al., 2009; Maier et al., 2015; Somech & Zahavy, 2013).

Team creativity can be defined as the team's ability to generate original, elegant and high-quality novel solutions to problems faced (Harvey, 2013; Mumford et al., 2012). Whilst team innovation refers to the team's ability to implement the novel ideas generated to solve successfully said problems faced (Somech & Zahavy, 2013).

Although there are differences in both concepts, both are interrelated and integral to a team's problem-solving ability. The process of creativity refers to the generation of new and novel

ideas that are potentially useful towards the organisation in the short or long term (Mumford et al., 2012; Eisenbiss et al., 2008). After the creative idea generation process is complete, the second and subsequent step involves the process of innovation implementation, which refers to the evaluation and successful implementation of the novel ideas generated (Harvey, 2013; Somech & Zahavy, 2013).

The current literature review on factors affecting team creative and innovative performance identified two trends. The first trend was that team dynamics was the most vital and essential driving force of team creativity and innovation performance due to better communication and information exchange (Apesteguia et al., 2012; Barczak et al., 2010; Johnson et al., 2000; Li et al., 2018; Pisani, 2012; Warner et al., 2012; Zoltan, 2015). The second trend was that previous research had focused on highlighting and introducing factors, interventions and processes to improve team idea-generating abilities. There was a consensus that generating and evaluating a wider pool of ideas would increase the odds of producing a novel solution for implementation and subsequently improve team creative and innovative performance (Dean et al., 2006; Edmonson, 2018).

This meant very little attention was paid towards the role of a team's dynamics in the problem-solving process, especially regarding the role of team dynamics within the team's ability to generate innovative and novel ideas and successfully implement them after critical evaluation (Hulsheger et al., 2009; Maier et al., 2015; Somech & Zahavy, 2013). Although studies suggest a link between creativity and innovation, where high idea generation levels typically result in better solutions, scholars argue that more frequently, creative and novel ideas are generated way more than actual implementation (West, 2012). A potential explanation for this phenomenon could be the higher complexity and risk commonly associated with novel, untested ideas (Anderson et al., 2014).

As novel ideas typically involve new and often radical changes in behaviours, procedures and practices, it would inevitably cause friction and scepticism among risk-avoidant team members and result in arguments (Anderson et al., 2014; Baer, 2012). This could originate from a lack of communication and interaction between team members and, if unmanaged, could negatively impact subsequent team member participation rate and information exchange (Anderson et al., 2014; Baer, 2012). These findings highlight the importance and role of team dynamics towards the team's effectiveness in innovation and problem-solving.

Relationship between team dynamics and creativity and innovation

The literature highlights the two components of team dynamics associated with effective high-quality team meetings that will be examined within this PhD: a team's Total Interaction Frequency (TIF) and Participation Equity Rate (PER). As mentioned, the consensus within the current literature on team dynamics and communication views a team's TIF as one of the crucial factors determining a team's effectiveness and performance (Apesteguia et al., 2012; Barczak et al., 2010; Breslin, 2019; Zoltan, 2015). This is because the TIF or team members' input forms the pool of information used to formulate the solution to complete their given task (Hülsheger et al., 2009; Marlow et al.,2018). Empirical studies have also found that increased TIF and openness of communication would generally improve team performance resulting from increased information exchange and learning (Bui et al., 2019; Marlow et al., 2018).

Another trait of high-performing teams, as identified by academics (Bear & Woolley, 2011; Cauwelier, 2019; Samrose et al., 2018; Woolley et al., 2010) and Google's Project Aristotle (Duhigg, 2016; Google, 2015), is more balanced PERs. Teams that had more balanced PERs grant opportunities for all team members to voice their opinions and ideas to be heard by the rest of the team, thus allowing for optimal ideas and solutions to be adopted to resolve the problem faced (Cauwelier. 2019; Duhigg, 2016; Google, 2015; Samrose et al., 2018;2020).

The results of these studies suggest that a team's TIF and PER could make the difference between high and low-performing teams.

Despite the numerous research studies on effective team dynamics and its links to team creativity and innovation, researchers and practitioners face issues and challenges when developing and applying good practice guidelines. The first issue, as mentioned, is the large number of interrelated factors affecting team dynamics, such as quality and type of interactions, making it harder to make conclusive statements about individual factors and their effects on team dynamics and effectiveness (Apesteguia et al., 2012; Bell et al., 2011; Johnson et al., 2000; Li et al., 2018; Pisani, 2012; Stahl et al., 2010; Thatcher & Patel, 2011; Warner et al., 2012; Zoltan, 2015).

The second issue is the contradictory results of previous studies (Bell et al., 2011; Stahl et al., 2010; Thatcher & Patel, 2011), resulting in disagreements and confusion among researchers and practitioners. This could be due to the failure to account for situational & task context (e.g., creativity and innovation vs sales and technical) and how it might affect the interrelationships between said factors (Bell et al., 2011; Stahl et al., 2010; Thatcher & Patel, 2011). More recently, scholars have also called for distinguishing the different types of verbal interactions and the quality of verbal exchanges during team meetings as they were found to have different relationships with a team's performance (Marlow et al., 2018).

These issues combined have also contributed to a situation where practitioners and educators erroneously assume a one-size-fits-all approach to evaluating a team's dynamics and communication on a team's effectiveness and performance (Marlow et al., 2018; Murase et al., 2012). This has resulted in practitioners believing that effective team collaborations can be achieved by replicating high frequency/amounts of the traits and behaviours exhibited by high-performing teams (Marlow et al., 2018; Murase et al., 2012). However, blindly following said

guidelines without accurately understanding a team's dynamics and communication profiles could potentially harm the team's effectiveness (Marlow et al., 2018).

An example would be previous research finding that negative communication behaviours (e.g., personal attacks; criticizing others) could affect team member satisfaction, dynamics and performance (Kaufield & Lehmann-Willenbrock, 2012; Weiss et al., 2018), and these adverse effects are more pronounced than positive outcomes derived from positive interactions such as supporting teammates and encouraging others to speak up (Kaufield & Lehmann-Willenbrock, 2012; Weiss et al., 2018). However, adopting a one-size-fits-all approach might see teams avoiding specific processes or behaviours deemed aversive to team collaborations but beneficial to team creativity and innovation, such as task-related arguments and conflicts (Chen, 2006; Kurtzberg & Mueller, 2005; Yong et al., 2014).

As such, there is a need for better methods and analysis to investigate further the antecedents and factors affecting team dynamics and its subsequent effects on a team's creative and innovative performance using 21st-century tools. There have been calls for interventions to improve team collaboration effectiveness that leverages current technological advances which move beyond traditional teambuilding training and workshops (Boughzala & De Vreede, 2015; Constapel et al., 2019; Figueroa et al., 2013; Xiao et al., 2013; Samrose et al., 2018).

The effects of virtuality on team dynamics, creativity, and innovation

Over the past decades, organisations and companies workflow designs have incorporated aspects of virtual team collaborations to boost productivity as it removes the space and time barriers associated with geographically remote and dispersed team collaborations (Acai et al., 2018; Alexander et al., 2012; Samrose et al., 2018). Technological advances have also led to the digitalisation of the 21st-century workplace, from the adoption of emails to instant messaging and the gradual shift towards virtual conferencing platforms (Barak & Usher, 2019; Fowler, 2014). The trending shift from "traditional" face-to-face (F2F) to technology-aided

virtual team collaborations has resulted in scholars and practitioners investigating the factors impacting the effectiveness of virtual team collaborations (Acai et al., 2018; Samrose et al., 2018).

More recently, virtual video conferencing platforms, such as Zoom, Skype, Microsoft Teams, and Google Meet, were developed and released. However, there is a relative lack of research on team dynamics of effective virtual video team collaborations compared to those focusing on cognitive and logistical elements (Acai et al., 2018; Alexander et al., 2012;). There were beliefs and expectations that given the platforms' ability to replicate F2F meetings virtually fully, good F2F practice guidelines would be applicable (Acai et al., 2018; Singh et al., 2021; Waizenegger et al., 2020). Those beliefs and expectations were tested during the Covid-19 Pandemic lockdowns, which saw organisations adopt full remote working models via virtual video team collaborations to maintain organisational productivity (Brenan, 2020).

At the pandemic's start, there was an apparent lack of appropriate 'guidance and recommended good practices' for effective online video-based collaborations and meetings (Belanger et al., 2021; Singh et al., 2021; Waizenegger et al., 2020). This led to the swift establishment of good practice and communication guidelines from the available literature on effective F2F and virtual team collaborations to facilitate effective virtual team collaborations (BPS, 2020; Singh et al., 2021; Waizenegger et al., 2020). However, even with those guidelines, organisations and practitioners still encountered challenges regarding effective team communication and dynamics during virtual team collaborations (Belanger et al., 2021; Singh et al., 2021; Waizenegger et al., 2020).

The first was the presence of signs that individuals were starting to suffer from "Zoom fatigue", in which individuals are worn-out after a full day of virtual interaction. One possible explanation for "Zoom fatigue", as documented in the media, was that individuals had an increased number of shorter meetings to attend during the lockdown as compared to their pre-

pandemic schedules (DeFilippis et al., 2020; Fosslien & Duffy, 2020; Jiang, 2020; Wiederhold, 2020). As such, scholars have started questioning whether certain aspects of online meetings, such as camera usage, would affect a team's dynamics and effectiveness (Wiederhold,2020).

To help combat the rising tide of individuals suffering from "Zoom fatigue", some scholars and practitioners suggested turning Cameras off during virtual meetings/collaborations to reduce the amount of "Zoom fatigue" individuals feel (Moses, 2020). The issue was that it contradicted previous research findings that active cameras during virtual meetings improve individuals' social presence and interaction during the session (Tasir & Al-Dheleai, 2019). It also raises the question of whether camera usage during online meetings would impact a team's dynamics and performance. Given the little empirical work on factors affecting effective online video collaborations, there was little to no investigation of the effects of camera usage in online collaboration sessions (Nadler, 2020; Wiederhold,2020).

These challenges faced during the start of the COVID-19 pandemic highlighted a few issues within the currently available literature investigating effective team dynamics for F2F and virtual team collaborations. The first issue was most research studies investigating virtual team dynamics and effectiveness was primarily conducted on text (email) and voice-based (telephone) conferencing platforms because of the availability of technology and user rates then (Gilson et al., 2015). These findings suggest that online teams had increased PER (Fowler, 2014), poorer creativity/innovation (Barak & Usher, 2019) and lesser verbal interactions as compared to F2F teams (Axtell et al., 2004; Golden & Raghuram, 2010). However, most of these findings were not directly applicable due to the mass adoption of virtual team collaborations on video conferencing platforms during the pandemic.

The second issue was most empirical studies pre-pandemic on effective virtual team collaborations focused on investigating cognitive and logistical factors affecting individuals during virtual meetings (Acai et al., 2018; Alexander et al., 2012). Little research directly

researched how virtuality could impact team dynamics and effectiveness during virtual team collaborations. The final issue was that studies investigating the team dynamics of effective team collaborations for both F2F and virtual teams yielded inconsistent results, possibly due to the interaction and combination of the abovementioned factors (Bell et al., 2011; Breuer et al., 2016; Gilson et al.,2015; Stahl et al., 2010; Thatcher & Patel, 2011).

All three issues saw the published guidelines at the start of the Covid-19 pandemic having limited information on the different nuances & characteristics between F2F and online video-based collaborations. Hence, individuals and organisations reading said guidelines might have adopted one-size-fits-all strategies that might not be suitable and primarily based on F2F teamworking guidelines. This could have led to problems and challenges during online team collaborations on video-based synchronous communication platforms.

With recent surveys indicating workers preferred having some elements of virtualisation within their post-pandemic work arrangements, organisations (e.g., Google, Xerox, Microsoft, etc.) have refined and expanded on their employees' remote working policies (Brenan, 2020). This suggests that remote working and virtual team collaborations are becoming the norm in the post-pandemic workplace and highlights the importance of 1) understanding the team processes and dynamics that facilitate effective virtual team collaborations, 2) obtaining further insights about team creativity and innovation within virtual collaboration platforms, and 3) interventions that could improve the effectiveness of virtual team collaborations such as providing teams feedback about their dynamics and processes (Gilson et al., 2015; O'Neil et al., 2018, 2020).

Providing teams feedback as an intervention

In their meta-review, Gilson et al. (2015) highlighted the importance of utilising an accurate and efficient recording/measuring of a team's dynamics to address the three points mentioned above. The use of behaviour analysis could provide accurate, high-quality, and objective

summaries of a team's dynamics that would provide further insights and understanding regarding the nuances and differences of team dynamics and processes between F2F and virtual team collaborations in various contexts (O'Neil et al., 2018, 2020). These summaries could also provide feedback to teams about their communication patterns to improve their dynamics and effectiveness in subsequent sessions (Figueroa et al., 2013; O'Neil et al., 2018, 2020; Xiao et al., 2013).

Conducting behaviour analysis of team meetings to obtain information and formulate feedback is increasingly being adopted by organisations as research has shown it to improve team dynamics, performance, and creativity (Gabelica et al., 2012; Johnson et al., 2013; Kauffeld & Meyers, 2009; Komaki et al.,1977; Smith & Ward, 2006). Behaviour analysis has the advantage of observing teams non-intrusively (Keyton, 2018) and providing the detailed summaries required to provide high-quality feedback to teams (Farley et al., 2018). Accurately documenting and using a team's dynamics summary to provide feedback would be a cost-effective and valuable training tool for identifying distressed teams who need support. The data obtained would allow for targeted feedback, which would help improve the team's dynamics and effectiveness in subsequent sessions or tasks (Breuer et al., 2016; O'Neil et al., 2018, 2020).

Providing teams with feedback could improve team effectiveness (Gabelica et al., 2014a, 2014b; Johnson et al., 2013) as it allows for increased team learning through reflection resulting in improved future team dynamics and performance (Gabelica et al., 2012). Previous studies found that regardless of virtuality, providing team communication (dynamics) feedback could help modify and improve a team's future dynamics and effectiveness, especially for underperforming teams (Breuer et al., 2016; Fallon et al., 2015; Gabelica et al., 2012, 2014a, 2014b; Konradt et al., 2015; O'Neil et al., 2018, 2020; Peñarroja et al., 2017; Tausczik & Pennebaker, 2013). Using these summaries and analyses makes team members aware of their performance and behaviours exhibited within the meeting (Farley et al., 2018; Kaufield et al.,

2006). It would also allow for individual reflection on the behaviours exhibited during the previous session and conclude if any modifications from themselves are needed to improve team dynamics, performance and creativity in future team meetings (Gabelica et al., 2012, 2014a, 2014b).

As mentioned in Chapter 1, most coding systems and schemes measuring team dynamics use retrospective coding and analysis of audio-video recordings and too many coding categories to be feasible for real-time team coding. The nature of retrospective coding also sees delays in feedback being presented to teams about their dynamics. The lack of technologically aided portable real-time verbal behaviour coding systems could explain the lack of research investigating the effectiveness of providing teams feedback about their dynamics immediately after the event.

More recently, scholars and researchers sought to develop more research investigating interventions where teams are provided feedback immediately after sessions for review before subsequent events begin (Farley et al., 2018; Samrose et al., 2018; 2020; Sarda et al., 2014). Previous research has shown that providing feedback immediately after an event (Farley et al., 2018) would enhance its effectiveness, given the events of the session are still vivid within individual minds (Thornock, 2016). This is known as short-cycle feedback and involves analysing coded data in real-time and using the analyses to provide feedback which may see modifications of behaviours in individuals towards desired levels (Brauner et al., 2018).

Recent studies have also seen the use of technologies and artificial intelligence to record and present summaries of team members' verbal interaction profiles as feedback to modify team dynamics during virtual meetings (Samrose et al., 2018; 2020; Sarda et al., 2014; Tausczik & Pennebaker, 2013). However, they are only limited to use within virtual conferences or for

retrospective analysis of recordings (Samrose et al., 2018; 2020; Sarda et al., 2014; Tausczik & Pennebaker, 2013).

Summary and hypotheses development

After reviewing the literature, a series of empirical studies were developed to test the effectiveness of a portable live real-time verbal behavioural coding system and its ability to provide the data required to provide effective short-cycle feedback to teams about their dynamics. The studies would also help provide answers and further insights into the research questions (Chapter 1) and the following hypotheses formulated below:

1) A team's dynamics are significantly related to the team's creativity and innovation.
    a. A team's TIF is significantly positively related to the team's creativity and innovation.
    b. A team's PER is significantly inversely related to the team's creativity and innovation.
2) Virtuality would impact a team's dynamics and performance.
    a. F2F teams would outperform virtual teams on the same task.
    b. F2F teams would have higher TIF than virtual teams.
    c. Virtual teams would have more balanced PER.
3) Camera usage would impact a virtual team's dynamics and performance.
    a. Virtual teams with Cameras on would have better creative and innovative task performance compared to teams with Cameras off.
    b. Virtual teams with Cameras on would have higher TIF compared to teams with Cameras off.
    c. Virtual teams with Cameras on would have more balanced PER compared to teams with Cameras off.

4) Providing teams with feedback about their team dynamics as an intervention would improve their subsequent task dynamics and performance regardless of virtuality.
    a. Teams receiving feedback would have better task performance.
    b. Teams receiving feedback would have increased TIF.
    c. Teams receiving feedback would have more balanced PER.

The following chapter will explain in further detail the theoretical underpinnings of verbal behaviour analyses, how it addresses the limitations mentioned above from the literature and how it helps answer the formulated hypotheses above and research questions in Chapter 1.

Chapter 3 Methodology

This chapter provides an overview of utilising verbal behaviour analysis to measure a team's dynamics and introduces Rackham's Behaviour in Teams (BiT) coding system and iPad app. It also describes how it codes a team's verbal behaviours and uses the data summaries it produces to provide feedback to teams as an intervention in the empirical studies of this PhD. The later part of this chapter will describe the tasks used to measure team creativity and innovation performance and justify their uses.

Verbal behavioural coding and analysis

Verbal behaviour analysis is a form of interaction analysis that systematically codes sequentially and naturally occurring verbal interaction behaviours between individuals and teams. It involves using verbal behaviour coders that interpret and code verbal interactions uttered during conversations into the categories within the coding schemes or systems used (See Table 3-1 below for an example). The summaries of coded data would provide descriptive data about the team's dynamics and allow interpretations and inferences about individual or sequence occurrences of the observed verbal behaviours within the context of the situation.

Table 3-1. Example of a transcript coded with the relevant verbal behaviour category of the Behaviour in Teams (BiT) Coding System.

Participant	Content	Category
002	How long are we making the bridge that we can measure? How long?	Seeking Task information
001	I would say we don't need more than three straws, realistically, Like all connected together.	Proposing Idea
002	So is this length good enough?	Checking Understanding
001	Well, if we cut longer than the actual string, we can always cut it shorter.	Seeking task Information
002	Ok. That's good to know.	Providing personal information
001	So right, so…?	Seeking task Information
002	Just draw them or something	Proposing Procedure

Using verbal behaviour analyses gives practitioners and researchers an overview of the team's interactions frequencies and distribution. It also helps reveal the temporal sequences of the teams' interactions which could allow trends and patterns of verbal behaviours to be identified. These details would allow for better predictability and understanding of how and when individual or sequences of verbal interactions could occur while accounting for appearances in unexpected contexts.

Using verbal behaviour analysis within a research design sees several requirements and assumptions that must be fulfilled (Brauner et al., 2018). The first being coders would be extensively trained to use a reliable and valid coding system to code all observed verbal behaviours and make valid and reliable judgements about them. Second, the coded interactions must not be scripted and be sequentially captured to provide the data needed for the required data analyses. Third, higher frequencies of coded behaviours are also assumed to be theoretically more important than the others, given their majority stake within the coded interactions. Fourth, the coding system must define what constitutes a codable act that fits into its categories.

Existing verbal behaviour coding systems and schemes

Many coding schemes and systems have been developed to measure various aspects of a team's dynamics and interactions. These systems are also used to provide teams with feedback about their interactions and dynamics (Brauner et al., 2018). However, a review of existing schemes and systems led to the shortlisting of the Behaviour in Teams (BiT), Act4teams coding scheme, and Interaction Process Analysis to be used in the methodology of this PhD. The three schemes/systems above were shortlisted for their ability to exhaustively code all verbal behaviours uttered by team members into individual verbal behaviour categories and produce data summaries required to provide teams with feedback (Brauner et al., 2018). However, further comparisons between the three shortlisted systems found that the BiT coding system is

most suitable for the empirical studies planned for this PhD (See Table 3-2). The following part will describe the comparison factors and the rationale for choosing the BiT coding system.

An important consideration during selection was the ability of the scheme/system to support accurate live verbal behavioural coding and provide the data necessary to provide short-cycle feedback. The comparisons highlighted the BiT coding system's ability to live-code a team's verbal behaviours into 15 distinct and separate categories via its dedicated iPad app, which can produce data summaries required to provide feedback instantly. In contrast, the Act4teams and IPA schemes are more suitably used for retrospective coding and analysis of audio-video recordings. The lack of a dedicated program and the many categories of the Act4teams (44 categories) scheme also restricts its ability to be used in live coding sessions. Similarly, the IPA's focus on coding a verbal behaviour's function over its content makes it hard to conduct live verbal behavioural coding and provide immediate feedback without further retrospective analysis.

Table 3-2. Comparison of Verbal behaviour coding schemes and systems available.

Coding system	No. of categories	Method of coding	Coder Training Time	Available versions
BiT Coding System (Farley et al., 2018; Rackham et al., 1971)	**15 categories (4 meta categories)**	**Live (real-time) and retrospective**	**20 hours**	**Pen and paper, Dedicated iPad app**
Act4teams Scheme (Kauffield et al., 2018)	44 categories (4 meta categories)	Retrospective	200 hours	Coding Scheme only No dedicated program
Interaction Process Analysis (Bales, 1950a, 1950b)	12 categories (4 meta categories)	Retrospective	No established training manual	General Methodology, No dedicated program

Although all three schemes and systems can be used to provide teams with feedback, the nature of retrospective coding and analysis sees a long delay in producing data summaries needed to

provide feedback, which subsequently reduces the given feedback's effectiveness (Farley et al., 2018; Thornock, 2016).

Another aspect to consider when selecting a scheme/system for use within the empirical studies of this PhD was the training required for coders to be proficient with the chosen system/scheme. The relatively shorter 20-hour training time for coders to be proficient with the BiT coding system provides another logistical advantage over the Act4teams and IPA schemes. Considering the combination of factors mentioned above led to the selection of the BiT coding system to be used within the empirical studies of this PhD. The following sections will provide an overview of the development and validity of the BiT coding system.

The Behaviour in Teams (BiT) Coding System

The BiT coding system is a variation of the Behaviour Analysis Coding System (BACS) developed by Rackham et al. (1971). It uses a behavioural analysis approach and a system of categories to live code verbal behaviours uttered by team members during meetings and improve team communications during subsequent sessions (Farley et al., 2018). The behaviour analysis approach aims to use accurate real-time coding and analysing of team interactions to obtain objective data and provide immediate post-session feedback to improve the team's interactions. The behaviour analysis coding system has its roots in psychomotor skills training which proposes that behaviour changes can be achieved by providing feedback derived from an accurate measurement of said behaviours (Farley et al.,2018).

Conducting verbal behaviour analysis of meetings using the BACS is done by interpreting the sequential verbal behaviours uttered by team members based on their content and coding them into different behavioural categories (e.g., Supporting, Disagreeing, etc.) during a session (Farley et al., 2018). There are multiple criteria to adhere to when establishing relevant verbal behaviour categories to be used by observers (coders) during sessions. These criteria propose that categories must be meaningful to observers (coders) and participants, be mutually

exclusive and describe the verbal behaviours to be coded. The categories' definitions and descriptions can change during/after coder training and be modified to fit the context/situation. The categories must also relate to the outcomes of the team's interactions and have high inter-rater reliability amongst coders trained on the variation of the system (Farley et al., 2018; Morgan et al., 1974; Rackham & Morgan, 1977; Rackham et al., 1971). It is also important to note that behaviour analysis should be viewed as a process to accurately quantify a team's verbal behaviours and interactions rather than a specific set of categories (Farley et al., 2018).

Rackham et al. (1971) initially developed and tested five categorical systems during a four-year research project with the British Overseas Airways Corporation (now known as British Airways) to train supervisory teams in communication skills. Conducting cluster analyses on the obtained data and five categorical systems produced four meta-behaviour categories that reflected how different behaviours are used, forming the framework and foundation of the BACS (Farley et al., 2018; Morgan et al., 1974).

The framework classified individual verbal behaviours categories into one of the four meta-categories, namely Initiating (behaviours related to idea and suggestion creation), Clarifying (behaviours that improve a team's common understanding), Reacting (behaviours that establish agreements and disagreements), and Process behaviours (behaviours that balances team participation interaction rates).

At its introduction, the BACS is one of the prevalent approaches to quantify and obtain objective data regarding a team's verbal behaviours in real time. Following this, several system variations were developed for different task contexts (Farley et al., 2018). This also highlights one of the biggest advantages for researchers and practitioners using the BACS: its ability to modify the categories to suit the context of the research or training goals as long it adheres to the behaviour analysis criteria listed above (Farley et al., 2018).

More recently, researchers have examined the effectiveness of utilising behaviour analysis and the BACS as educational tools to develop student teamwork in higher education via training and feedback (Farley et al., 2018). A research program aptly named the Behaviour in Teams project started in October 2015 at the University of Sheffield (2018) and saw the development of the 15-category Behaviour in Teams (BiT) coding system, which is a variation of the original BACS categories that were initially developed for work teams (Farley et al., 2018).

Table 3-3. The 4 meta categories and 15 individual BiT Behaviour Categories

Initiating Behaviours: behaviours related to idea and suggestion creation	
1. ***Proposing Procedure***:	The speaker puts forward, directly or indirectly, an actionable new procedure or team organizing method that relates to how the task or meeting output will be achieved.
2. ***Proposing Ideas:***	The speaker puts forward, directly or indirectly, an actionable new idea that relates to the task or meeting output being discussed.
3. ***Building:***	The speaker puts forward, directly or indirectly, an actionable new suggestion that obviously develops or extends another person's proposal.
Clarifying Behaviours: behaviours that improve a team's common understanding	
4. ***Supporting Ideas****:*	The speaker tells others present she/he agrees with or supports the ideas or task-related opinions of another team member.
5. ***Supporting People:***	The speaker expresses personalized support to another person present, for their contributions, efforts, or abilities.
6. ***Disagreeing****:*	The speaker directly disagrees, raises objections or puts up obstacles to another person's proposals or opinions.
7. ***Defending / Attacking****:*	The speaker directly attacks, negatively evaluates another person, or defensively blames others.
8. ***Checking Understanding:***	The speaker asks questions that check whether there is a shared understanding of another team member's contribution, or of what has been discussed or decided by the group.
Reacting Behaviours: behaviours that establish agreements and disagreements	
9. ***Seeking Personal Information:***	The speaker asks others present about personal facts, activities, anecdotes, concerns or feelings.
10. ***Seeking Task Information:***	The speaker asks other questions about task-related facts and opinions, and things indirectly relevant to doing the task.

11. ***Giving Personal Information:***	The speaker discloses information about personal facts, activities, anecdotes, concerns or feelings.
12. ***Giving Task Information:***	The speaker gives facts, opinions, and clarifications relating to the task or the broader work of the team, to other team members.
Process Behaviours: behaviours that balances team participation interaction rates	
13. ***Shutting Out:***	The speaker excludes another person or reduces their opportunity to participate.
14. ***Bringing In:***	The speaker invites task-related contributions from a member of the team who is not actively participating in the discussion.
15. ***Lightening The Mood:***	The speaker tells jokes, or makes humorous interjections.

The BiT research program has successfully used the 15-category BiT coding system within multiple research projects to live code a team's verbal behaviours and evaluate the efficacy of using its data summaries to provide teams with short-cycle feedback immediately after sessions (Farley et al., 2018). This included an experimental study that live-coded the verbal behaviours of 139 student teams divided into different research conditions across a two-week-long project, with some receiving immediate short-cycle feedback about their team dynamics and processes (Farley et al., 2018; University of Sheffield, 2018). Following its success, it led to other research projects investigating the use of live verbal behaviour coding of teams and the effectiveness of providing them feedback (University of Sheffield, 2018). This also influenced the development of the empirical studies conducted within this PhD.

The 15 categories (See Table 3-3) are considered intuitive and easily understandable for both observers (coders) and participants and can capture and document almost any verbal behaviour exhibited by members into at least one category (Farley et al., 2018; Rackham & Morgan, 1977). If a behaviour does not fit into the 15 categories, a separate category called 'others' can be used to record said behaviours (Farley et al.,2018).

Although traditionally used in a paper and pen format, technological breakthroughs have allowed the BiT coding system to be modernised and ported into an app compatible with Apple iPads (see Figure 3-1) and equivalent versions available for Windows computers. The iPad app

version simplifies the coding process for observers (coders) as recording behaviours in real time only requires a tap of the participant's name and the category the exhibited behaviour falls into.

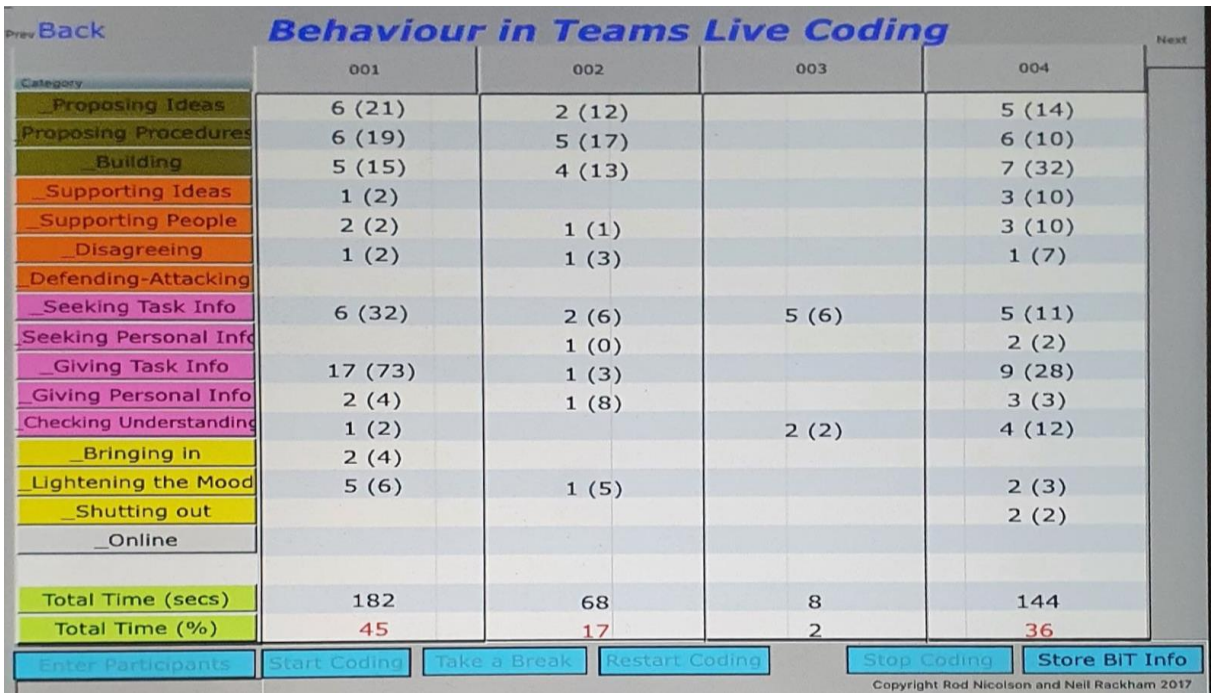


Figure 3-1: Screenshot of a post-live-coding summary of behaviours using the BiT Coding iPad app.

The most prominent advantage of the BiT coding system with the newly developed iPad app compared to similar verbal behaviour coding systems (Brauner et al., 2018; Kaufield et al., 2018) is the observer's (coder) ability to instantly obtain detailed summaries of a team's dynamics and communication profile at the end of a session. This would allow the researchers and teams to view detailed graphical analyses of the team's total interaction frequencies (TIF), team members' contributions and a breakdown of the 15 individual verbal behaviour categories exhibited during the meeting (Farley et al., 2018). The ability of the BiT coding system to instantaneously generate these summaries provides opportunities to provide feedback at the first instance after the event's occurrence and potentially observe the feedback's effectiveness (Thornock, 2016).

Further analyses utilising the team's TIF and individual member contributions would also provide the team's participation equity rate (PER) via a team's standard deviation (SD) of verbal behaviours frequencies. The SD represents the scatter of verbal behavioural frequencies across the individual team members. An SD closer to 0 indicates that the team have a similar and almost equal distribution of verbal interactions with each other and, therefore, a good cross-team balance. A high SD could result from different permutations of communication patterns, for example, two unequal clusters within a team (one being silent while the other is speaking all the time) or different individuals talking over others when they try to speak up.

Regardless of the potential possibilities, a high SD could signal an issue with a team's dynamics and communication that might subsequently affect a team's performance and effectiveness (Cauwelier, 2019; Duhigg, 2016; Google, 2015). This method of scoring and analysing the coded data is similar to the approach Cauwelier (2019) and Google's Project Aristotle (Duhigg, 2016; Google, 2015) took when investigating the relationships between a team's PER and effectiveness.

Observer training for the BiT coding system

As mentioned above, observers (coders) wanting to utilise the BiT coding system require specialist training to ensure objective and accurate coding of verbal behaviours with high inter-rater reliability (Farley et al., 2018). The BiT coding system training course, which takes around 20 hours on average, was designed for observers to: 1) gain proficiency and expert knowledge of the criteria set for each behaviour category, 2) accurately distinguish and code verbal statements of team members into the respective categories, and 3) provide feedback to the teams about their verbal interaction patterns neutrally and factually.

The training for the observers consisted of two parts, the first being a video-based learning course found on the iPad app version of the BiT coding system, followed by a face-to-face

facilitator-led training session. The video-based training required observers to watch pre-recorded videos introducing the 15 categories in sequence and practice coding the various categories using pre-recorded audio tapes provided in the BiT iPad app. Observers needed to pass the video-based training session before attending the facilitator-led training session to live-code simulated live team meetings.

The observers' coding accuracy was monitored throughout the training via a Cohen's kappa value obtained at the end of each simulated audio tape or mock coding session. The Cohen's Kappa value was derived by comparing the observers' codes against the answer key in the BiT iPad app or provided by the facilitator during their session. Observers are considered to have passed the training course when their Cohen Kappa score on the final test given by the facilitator was equal to or higher than k =.85.

Providing teams feedback

As part of BiT coding training, observers are taught how to utilise the data analyses generated at the end of a session to provide teams with immediate feedback about their team dynamics. During the face-to-face training, observers were taught to provide team feedback which aligned with evidence-based and best-practice recommendations (Farley et al., 2018). It suggests that feedback should be provided by an impartial individual to the entire team immediately after the session and be given in a clear and non-threatening manner. Also, the observer should encourage the team to reflect on and evaluate the information provided. The method observers will give feedback to participating teams during the empirical studies of this PhD adheres to the principles. The main aim of providing teams feedback was to explicitly show individuals and the team their interaction patterns and give time for reflecting on the information provided with the steps listed below:

1. Observers will show and describe the summary of the team's coded verbal behaviours and patterns.
2. The team will be given opportunities to ask questions about each behavioural category and its meaning.
3. Observers will ask the team what they felt about their interaction patterns and what they thought about the feedback given.
4. Observers will conclude the feedback session by asking the team to note if changes were to be made to their interaction patterns before commencing the session.

The feedback session concluded by letting teams decide if modifications to behaviours were needed to improve their team's interaction patterns and performance. It is noted that the observer's role during the feedback session is to guide the team through a reflection process and avoid making statements during the feedback process that could elicit biases towards the observer's ideal of how a team should communicate.

Quantitative measures of team effectiveness

As mentioned in the literature review (see Chapter 2), this PhD would be measuring two aspects of team effectiveness, namely a team's creativity (idea generation performance) and innovation (creative problem-solving performance). This section describes the tasks used to measure both aspects of the team's idea generation and creative problem-solving performance during the empirical studies conducted within this PhD.

Measuring team creativity (idea generation)

This PhD used the Guilford Alternative Uses Tests (GAUT) to measure the team's idea generation performance. The GAUT, developed from Guilford's Structure of Intellect is a well-established tool widely used as a measure of a team's idea generation performance (de Bloom et al., 2014; Runco & Acar, 2012). The test generally involves individuals or teams listing all possible, creative, alternative uses for a specified object. The object used in the question can

be anything the question-setter pleases, with the most common items used being a pen or a brick (de Bloom et al., 2014; Runco & Acar, 2012).

The GAUT is scored by tallying the number of uses each team generated for the specified item. Similar and related uses were not counted to prevent inflation of scores, an example being "*boiling an egg*", "*scrambled eggs*", and "*omelette*" is classified as cooking an egg and tallied as one valid use; however, "*making a meringue*" or "*baking cakes*" would count for two different valid entries. The teams would each be given 5 minutes to discuss and complete the task, with the final tallied scores to be used as their team's idea generation performance.

Measuring team innovation (creative problem-solving)

This PhD used the egg-drop task (Chapter 4) and bridgebuilding task (Chapters 5 & 7) to measure a team's creative problem-solving performance, calculated using the specified scoring metrics at the end of the task. Both online and face-to-face educational courses teaching teamwork and communication skills have used variations of both tasks as they have objective performance measures, require minimal specialist expertise and different teams with the same set of resources can derive various solutions (Dow et al., 2009; Ferguson et al., 2010; Freiermuth, 2002; Kang et al., 2011; Sullivan, 2011; Warner, 2005).

The nature and context of the tasks require teams to communicate as they would have to evaluate the given task and its parameters, generate ideas and then implement them to solve the given problems (Dow et al., 2009; Ferguson et al., 2010; Freiermuth, 2002). The teams would be briefed about the task instructions and objectives and given the same resources and time limit to complete the task objectives. The subsequent empirical chapters would provide more details about the task parameters, available resources, and scoring metrics for the task used in that study.

Chapter 4 Egg drop

Introduction

As discussed in the literature review (Chapter 2), creative and innovative team collaborations are crucial to organisations obtaining a competitive edge over their competitors (Hulsheger et al., 2009; Maier et al., 2015). One of the most vital and essential driving forces of a team's creativity and innovation performance was their team's dynamics (Apesteguia et al., 2012; Barczak et al., 2010; Johnson et al., 2000; Li et al., 2018; Pisani, 2012; Warner et al., 2012; Zoltan, 2015). The two aspects commonly associated with and measured in team dynamics studies are the team's total interaction frequencies (TIF) which refers to the total quantity of verbal interactions exhibited by the team during tasks and participation equity rate (PER) which refers to the equality of verbal interactions exhibited by team members during tasks (Apesteguia et al., 2012; Breslin, 2018; Cauwelier. 2019; Duhigg, 2016; Google, 2015; Zoltan, 2015).

Empirical evidence has shown teams with increased TIF and more balanced PER to be more creative and innovative due to an increased rate of information exchange and opportunities for all team members to voice their opinions and ideas (Apesteguia et al., 2012; Breslin, 2018; Cauwelier. 2019; Duhigg, 2016; Google, 2015; Zoltan, 2015). Even with this knowledge, multiple challenges are faced in teaching and facilitating creative and innovative team collaborations. This could be due to the contradictory results of empirical research conducted (Bell et al., 2011; Stahl et al., 2010; Thatcher & Patel, 2011) and the lack of accurate distinguishing of the different types and quality of verbal exchanges during team meetings (Marlow et al., 2018).

These revealed the insufficient understanding of the interplay of team dynamics during creative team working to underpin a comprehensive applied science and allow for the formulation and teaching of best practice guidelines (Hulsheger et al., 2009; Maier et al., 2015). Practitioners

and educators have, as a result, erroneously adopted a one-size-fits-all approach when evaluating a team's dynamics and communication (Marlow et al., 2018; Murase et al., 2012). There is also a fallacy that effective team collaborations can be achieved by replicating a high frequency of traits and behaviours associated with high-performing teams (Marlow et al., 2018; Murase et al., 2012). However, blind following and replicating said "beneficial" traits and behaviours without an accurate understanding of a team's dynamics and communication profiles could be detrimental to the team's effectiveness (Marlow et al., 2018).

The literature highlighted two areas that would help further understand the interplay of team dynamics on creative team collaborations: 1) to use a methodology that objectively and accurately measures a team's dynamics and 2) to develop an intervention that could improve the effectiveness of team collaborations for subsequent tasks (Gilson et al., 2015). Further reviews of the literature led to the consideration of utilising live verbal behaviour coding of team meetings which would provide a much more detailed summary of the 'micro-dynamics' within a team (Farley et al., 2018; Kaufield et al., 2006; Rackham & Morgan, 1977; Tausczik & Pennebaker, 2013). The generated summaries could then provide teams with feedback about their dynamics and communication patterns and allow modifications to their communication patterns before the next task/session (Cauwelier, 2019; Gabelica et al., 2012; 2014a, 2014b).

This study utilised a quantitative approach and investigated the feasibility of using the Behaviour in Teams (BiT) verbal behavioural coding system to live code a team's dynamics during an idea generation (creativity) and creative problem-solving (innovation) task. It also evaluated the effectiveness of providing teams feedback on subsequent task dynamics and performance using the team and individual verbal behaviour summaries the BiT coding system generates. The teams' verbal behaviour summaries and performance during idea generation and creative problem-solving tasks would be used to address the following research questions and their accompanying hypotheses formulated from the literature review:

RQ1: How does a team's dynamics impact their creativity and innovation?

a. A team's TIF is significantly positively related to the team's creativity and innovation.
b. A team's PER is significantly inversely related to the team's creativity and innovation.

RQ2: What verbal behaviours affect a team's creativity and innovation?

RQ3: Does immediate communication profile feedback improve future team dynamics and creative and innovative task performance?

a. Teams receiving feedback would have better task performance.
b. Teams receiving feedback would have increased TIF.
c. Teams receiving feedback would have a more balanced PER.

Method

Participants

A total of first-year undergraduate students (20 females and 3 males) aged 18 to 21 years (M = 19.75, SD = 1.73) from Edge Hill University were recruited to participate in the study during a taught seminar on effective team working. This provided a total of 5 participant teams of four to five members. The participant teams recruited for this study all had at least eight continuous weeks of experience working together on academic projects.

Participants were not compensated for participating in this study, and it was emphasized that participation status in the study did not affect their academic grades to prevent feelings of coercion. The study received ethical approval from Edge Hill University's Psychology Department's Research Ethics Committee (Ref: BT/03-2019/064). All protocols for obtaining informed consent, GDPR and Debriefing were adhered to (See Appendix F for ethics forms).

Materials

Team Idea Generation: Guilford's Alternative uses task (GAUT)

The Guilford Alternative Uses Tests (GAUT) developed from Guilford's (1967) Structure of Intellect were used to measure the team's idea generation performance. The most common example of this test was "*Please list all the uses you can think of for a brick/pen.*" (de Bloom et al., 2014; Runco & Acar, 2012).

Similar and related uses were not counted to prevent inflation of scores, an example being "*boiling an egg*", "*scrambled eggs*", and "*omelette*" is classified as cooking an egg and tallied as one valid use; however, "*making a meringue*" or "*baking cakes*" would count for two different valid entries. The teams would each be given 5 minutes to discuss and complete the task, with the final tallied scores to be used as their team's idea generation performance.

Team Creative Problem-Solving: Egg Drop Task

A classic team-building task called the egg drop task was used to measure the team's creative problem-solving performance. Educators and workshops have used variations of the egg drop task in similar team creativity contexts to teach creativity and teamworking skills (Dow et al., 2009; Ferguson et al., 2010; Kang et al., 2011; Sullivan, 2011; Warner, 2005). The task required the participant teams to design and build a vessel from a given set of materials to protect a raw egg from a fall from three levels of height. The participant teams were each given 30 minutes and the following materials to create their vessel to protect their egg from damage during the drops.

1. One roll of scotch tape
2. Two pairs of scissors
3. Six dishwashing sponges
4. One black trash bag
5. One spool of string
6. One box of plastic straws
7. One raw egg.

Pilot studies showed that the choice of materials above would allow for a wide range of approaches and performance to the given task. The teams' performance was judged by dropping their vessels at three increasing heights. The height level of the first drop was from a participant who stood on a chair and released the team's prototype to the ground. The height level of the second drop was from the first floor to the ground floor of a building, and the height level of the final drop was from the second floor to the ground floor of the same building.

Participant teams were awarded points at the end of each drop using the following scoring table: 1 point - The egg fully cracked, and the contents spilt out; 2 points - The egg was slightly cracked and with contents mostly inside; and 3 points – The egg is fully intact with no damage or cracks.

If a team's egg was damaged or destroyed at the end of each drop, they were awarded the appropriate points but were eliminated from the following drop height. A maximum of nine points could be earned by completing all three drops without any damage or cracks to their egg.

Team dynamics: BiT coding

Given the exploratory nature of this study on the feasibility of utilising live behavioural coding to measure team dynamics, a simplified version of the established fifteen Behaviour in Teams (BiT) category coding system was used (Farley et al., 2018; Rackham & Morgan, 1977). The simplified version contained seven behaviour categories adapted from the original fifteen categories that were most probable to occur during team idea generation and creative problem solving (Hargadon & Bechky, 2006; Mesmer-Magnus & DeChurch, 2009; Nunamaker et al., 2009; Santanen et al., 2004).

A "none of the above" category was then added to represent all other behaviours not listed, which was recommended by the BiT coding manual (Farley et al., 2018; Rackham & Morgan, 1977). The final eight categories were used to live-code individual teams' verbal behaviours

and provided information for feedback to be given to teams in the experimental condition. Table 4-1 shows the eight categories used in this study.

Table 4-1. The eight verbal behavioural categories used to measure team dynamics for this study.

BiT Verbal Behaviour Categories			
1.	Proposing	2.	Building
3.	Supporting	4.	Disagreeing
5.	Seeking & Giving information	6.	Bringing in
7.	Shutting out	8.	None of the above

BiT observer training

The current study also served as part of the training programme for the BiT coding observers to be fully qualified to use the 15-category BiT coding system. Given that the eight categories above were adapted from the original 15-category BiT coding system, the observers coding the participant teams had to obtain expert knowledge and proficiency training in the above categories. The training included a video-based learning course on the BiT coding iPad app and a mini live coding session with a trainer.

The training required observers to watch pre-recorded videos introducing the listed categories in sequence and practice coding the various categories using pre-recorded audio tapes provided in the BiT iPad app. Throughout the training, observers had their coding accuracy monitored via a Cohen's kappa value supplied at the end of each simulated audio tape. Cohen's Kappa was derived by comparing the observers' codes of the tapes against the answers provided in the BiT iPad app, which was considered the "gold standard". Observers were deemed to pass the training when their Cohen Kappa score on the final test was equal to or higher than k =.85.

Obtaining a team's TIF and PER

The coded tallies of verbal behaviours the team and individual members exhibited for each task session would provide the team's TIF and PER. The total frequencies of verbal behaviours measured would indicate the team's TIF, with higher totals signalling that the team interacted and communicated more. The team's standard deviation (SD) of verbal behaviours frequencies would indicate the team's PER. The SD represents the scatter of verbal behavioural frequencies across the individual team members.

An SD closer to 0 indicates that the team have a similar and almost equal distribution of verbal interactions with each other, whilst a high SD suggests imbalanced participation equity. Regardless of the potential possibilities, a high SD typically signals an issue with a team's dynamics and communication that might subsequently affect a team's performance and effectiveness (Cauwelier, 2019; Duhigg, 2016; Google, 2015). This method of scoring and analysing the coded data is similar to the approach adopted by Cauwelier (2019).

Design

The current study utilised a two-condition between-subjects design: 1) the Control condition, where teams performed both experimental tasks without receiving feedback, and 2) the Feedback condition, where teams received feedback about their team's interaction patterns at specific intervals.

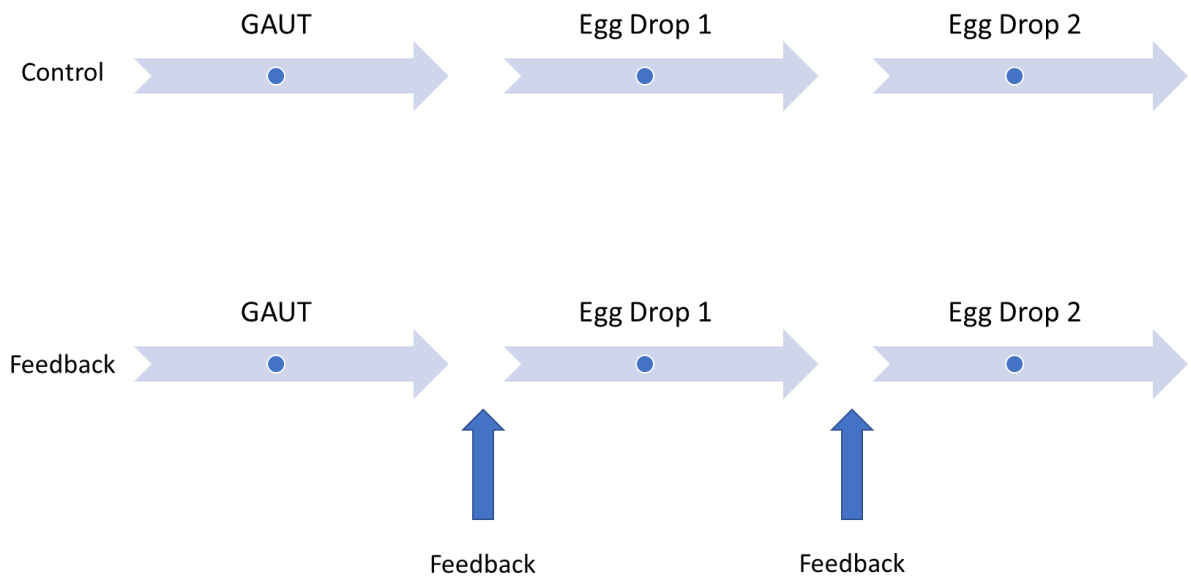


Figure 4-1. Flowchart depicting the entire study design and intervals designated to provide teams with team dynamics feedback

Figure 4-1 is a flowchart of the entire experimental flow and intervals where feedback is provided to the participant teams. Each participant team had a trained observer live coding their verbal interactions and used the data summaries to give feedback to teams in the feedback condition.

Providing teams feedback

As part of BiT coding training, observers were taught how to utilise the data analyses generated at the end of a session to provide teams with immediate feedback about their team dynamics. Observers provided feedback to the teams using the steps listed below:

1. Observers showed and described the summary of the team's coded verbal behaviours and patterns.
2. The team was given opportunities to ask questions about each behavioural category and its meaning.
3. Observers asked the team what they felt about their interaction patterns and what they thought about the feedback given.

4. Observers concluded the feedback session by asking the team to note if changes were to be made to their interaction patterns before commencing the session.

The main aim of the given feedback was to show both individuals and the team their interaction patterns explicitly and to provide time for reflecting on the information provided. The feedback session concluded by letting teams decide if modifications to behaviours were needed to improve their team's interaction patterns and performance. It is noted that the observer's role during the feedback session was to guide the team through a reflection process and avoid making the feedback process elicit biases towards the observer's ideal of how a team should communicate.

Procedure

Participants were recruited as teams of four to five members and briefed about the study before informed consent was obtained and basic demographic information was collected. Participant teams were then briefed on the GAUT instructions and given opportunities to ask questions before the task started. The participant teams were each given 5 minutes to list as many possible creative and alternative uses for an egg. At the end of the GAUT, teams in the feedback condition were given feedback about their team's dynamics.

The participant teams were then briefed about instructions and objectives for the egg drop task. The participant teams were given 30 minutes, broken into two 15-minute sessions (Egg Drop 1 and 2), to ideate and develop a vessel to protect their egg from damage when dropped from three increasing height levels with the materials provided. After the first 15-minute session had lapsed (Egg Drop 1), teams in the feedback condition were given feedback about their team dynamics before starting their second 15-minute session (Egg Drop 2).

The teams then took turns dropping their prototypes from the three specified heights, and the observer recorded the team's performance for the egg-drop task. The entire study took no more

than 1 hour, including the time to give teams feedback in the feedback condition. Participants were debriefed verbally at the end of the study and provided with a debriefing sheet.

Data analyses

Correlational analyses were conducted on the collected data of the team's TIF, PER, tallies of individual verbal behaviour categories with task performance scores for the GAUT and egg drop tasks. The analyses would provide further insights to help answer RQ1 (How does a team's dynamics impact their creativity and innovation?) and its associated hypotheses, namely:

a. A team's TIF are significantly related to the team's creativity and innovation.
b. A team's PER is significantly related to the team's creativity and innovation.

Further correlational analyses of the individual behaviour category tallies would also provide insights to help answer RQ2 (What verbal behaviours affect a team's creativity and innovation?).

A between-sample t-test was conducted to investigate the effects of providing teams feedback on their team dynamics on subsequent task performance and team dynamics. The TIF, PER, and task performance scores for the egg drop task were collated and used in the analyses. The analyses would provide further insights to help answer RQ3 (Does immediate communication profile feedback improve future team dynamics and creative and innovative task performance?) and its associated hypotheses, namely:

a. Teams receiving feedback would have better task performance.
b. Teams receiving feedback would have increased TIF.
c. Teams receiving feedback would have a more balanced PER.

Results

The data collected from all 5 participant teams were collated and analysed. The results were divided into four sub-sections. The first section compares the team's TIF & PER on their GAUT performance. The second section analyses the correlations between individual verbal

behaviours on the team's GAUT performance. The third section compares the overall effects of feedback on teams' TIF, PER and egg drop task performance for both experimental conditions. The final section conducts a detailed analysis that compares the impact of feedback on each team's TIF and PER from Egg Drop 1 to Egg Drop 2.

GAUT session data analyses

This section focuses on the data analyses examining the relationship of a team's TIF and PER on the number of ideas generated during the GAUT. The collated data from the 5 participant teams were used to conduct the data analyses required for hypotheses testing. The descriptive data for the number of ideas generated, TIF and PER by participant teams are shown in Table 4-2.

Table 4-2. Descriptive statistics and correlations of the team's recorded frequencies for TIF, PER, and number of ideas generated

	Mean	SD	1	2	3
1. TIF	47.20	17.94	-		
2. PER	5.10	3.54	.71	-	
3. Ideas generated	22.40	8.02	.88*	.72	-

A Pearson correlation test was conducted to test for significant correlations between a team's TIF (M = 47.2, SD = 17.94), PER (M = 5.10, SD = 3.54), and their GAUT scores (M = 22.4, SD = 8.02). The results indicated a strong significant correlation between a team's TIF and their GAUT scores (r = .88, p = .047). There was also a strong non-significant correlation between the team's PER and the number of ideas they generated (r = .72, p = .170).

Individual BiT behaviours on GAUT performance

Further correlational analyses were conducted between the team's behaviour category tallies and the number of ideas they generated to obtain further insight into which behavioural categories might significantly impact team idea generation. A summary of the correlations and significance levels is shown in Table 4-3.

Table 4-3. Pearson Correlations between the team's tallies of all eight individual verbal behaviour categories and the number of ideas they generated.

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1. Ideas generated								
2. Proposing	0.46							
3. Building	0.78	-0.19						
4. Supporting	0.39	-0.45	0.77					
5. Disagreeing	0.33	-0.38	0.64	.97**				
6. Giving information	0.29	-0.25	0.43	0.72	0.84			
7. Bringing in	-0.45	-0.16	-0.42	0.19	0.41	0.59		
8. Shutting out	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
9. None of the above	0.48	-0.30	0.82	0.78	0.61	0.15	-0.38	Nil

*Correlation is significant at the 0.05 level (2-tailed)

**Correlation is significant at the 0.01 level (2-tailed)

There were some strong correlations between the GAUT scores and the eight verbal behaviour categories, the most substantial being 'Building', r = .78, p =.121. However, the analyses showed that all correlations between GAUT scores and the behaviour categories were non-significant. There was a significant correlation between 'Disagreeing' and 'Supporting', but no significant correlations were found with the other behaviour categories.

Egg Drop Task data analyses

This section focuses on the data analyses examining the effectiveness of feedback in modifying a team's TIF, PER and creative problem-solving performance during the egg drop task. The collated data from the 5 participant teams were used to conduct the data analyses required for hypotheses testing.

Table 4-4. Descriptive statistics of the team's TIF, PER and performance for both experimental conditions during the egg drop task.

Condition/Variable	TIF		PER		Egg Drop Task Performance	
	Mean	SD	Mean	SD	Mean	SD
Control	143.00	82.02	10.83	7.18	9.00	0.00
Feedback	127.67	26.65	3.72	2.22	9.00	0.00

The descriptive data for the TIF and PER and egg drop task performance by participant teams are shown in Table 4-4. A between-sample t-test was conducted to test for significant differences in the team's TIF and PER between feedback and control conditions. The Levene's test for equality of variances for the team's TIF [$F(1, 3) = 36.83$, $p = .009$] and PER [$F(1, 3) = 26.50$, $p = .014$] found the assumptions of homogeneity to be violated. Owing to this violation, the results indicated that providing teams feedback about their team's dynamics did not significantly increase a team's TIF, $t(1.14) = -.26$, $p = .837$ or balance the team's PER $t(1.13) = -1.36$, $p = .385$ during subsequent task sessions.

The observers' notes about the egg drop task each team's prototypes showed that all five teams built similar prototypes resembling parachutes. Further tallying the teams' egg drop task performance results revealed a ceiling effect on this outcome measure where all teams scored the maximum points. This ceiling led to the inability to determine the relationships between a team's TIF and PER on their creative problem-solving performance and the impact of feedback on their creative problem-solving performance.

Further correlational analyses were made between the team's TIF and PER during the egg drop task to test for significant relationships for both experimental conditions. The analyses (See Table 4-5) showed a strong positive significant correlation between a team's TIF and PER for the control teams ($r = 1.00$, $p < .001$) and a strong positive non-significant correlation between the team's TIF and PER for teams in the feedback condition ($r = .99$, $p = .079$).

Table 4-5. The mean and standard deviation (SD) of the team's TIF and PER and Is correlation across both experimental conditions

	TIF		PER		Correlation	
	Mean	SD	Mean	SD	r-value	p-value
Control	143.00	82.02	10.83	7.18	1.00	.001*
Feedback	127.67	26.65	3.72	2.22	.99	.079

Detailed analyses of changes to individual teams' TIF and PER from the first to the second halves of the egg drop task

This section analyses the changes to an individual team's TIF and PER from the first half (Egg Drop 1) to the second half (Egg Drop 2) for both experimental conditions. Table 4-6 showcases the team's TIF and PER data across experimental conditions and egg drop task intervals.

Table 4-6. The TIF, PER and percentage changes to both elements between both halves of the egg drop task.

	1st half		2nd half		% from 1st to 2nd half	
	TIF	PER	TIF	PER	TIF	PER
Team 1 (Control)	119.00	16.54	82.00	15.29	-31.09%	-7.56%
Team2 (Control)	70.00	6.28	88.00	6.27	25.71%	-0.16%
Team 3 (Feedback)	42.00	6.99	43.00	4.51	2.38%	-35.48%
Team 4 (Feedback)	60.00	3.37	57.00	1.71	-5.00%	-49.26%
Team 5 (Feedback)	67.00	2.41	41.00	2.28	-38.81%	-5.39%

The analyses showed that regardless of feedback, all the teams had varying fluctuations in their team TIF from the first to the second half of the egg drop task. The analyses also showed that teams in the feedback condition generally had more balanced PER during the first half of the egg drop task. Teams in the feedback condition also had bigger % changes to their PER compared to control teams from the first to the second half of the egg drop task.

Discussion

The current study had three main aims: 1) to obtain further insights into the relationships between team dynamics and their creativity and innovation performance, 2) to evaluate the effectiveness of using the generated data to provide teams feedback to improve their subsequent task dynamics and performances, and 3) to evaluate the feasibility of using the BiT coding system for live verbal behavioural coding and analysis. The following sections will discuss how the results section answers the three research questions and their associated hypotheses of this study.

RQ1: How does a team's dynamics impact their creativity and innovation?

Correlational analyses were conducted on the participant teams' data from the GAUT to answer RQ1 and its associated hypotheses. The results showed that a team's TIF had a strong positive significant correlation with the number of ideas they generated. These findings support hypothesis 1a, which predicted a team's TIF is significantly positively correlated with their creativity (idea generation) performance. The results also align with previous research findings (Bui et al., 2019; Marlow et al., 2018) that suggested teams with a higher total number of interactions would have better team creativity scores due to more information exchange.

The results also showed a strong positive non-significant correlation between the team's PER and GAUT performance. These findings did not support hypothesis 1b, which posited a more balanced team PER improved team creativity (idea generation) performance. This finding also contradicted previous research on a team's PER and creativity performance (Duhigg, 2016;

Google, 2015). The findings indicate that a more imbalanced team PER resulted in teams generating more ideas. The strong positive correlation between a team's TIF and PER could explain this finding, suggesting that increasing a team's TIF might further imbalance their PER, but this imbalance benefits team creativity and idea generation.

The current study was conducted during a timetabled academic tutorial. Due to time restraints, the GAUT only consisted of one item. However, it has been recommended that the GAUT have at least two items of similar difficulty levels, which can account for item variation and obtain a more accurate measure of team creativity (de Bloom et al., 2014; Runco & Acar, 2012). Hence, future iterations of the GAUT should consist of two items, as evidenced in future empirical studies planned for this PhD.

RQ 2: What verbal behaviours affect a team's creativity and innovation?

Subsequent correlational analyses were conducted to answer RQ2 and understand which of the eight individual behaviour categories might impact a team's creativity (idea generation). The results showed strong but non-significant correlations between the eight behaviour categories and the team's GAUT scores. The strong correlations between the team's tallies of individual behaviour categories and their GAUT scores were to be expected as previous research has found them to affect team creativity (Hargadon & Bechky, 2006; Mesmer-Magnus & DeChurch, 2009; Nunamakeret al., 2009; Santanen et al., 2004).

Although the current findings support previous research findings and provide further insight to answer the research questions for this study, this pilot study's small scale and sample size presented limitations to generalising them. It is predicted that conducting the study with larger sample sizes would yield highly significant results given the current pattern of results for this study.

RQ3: Does immediate communication profile feedback improve future team dynamics and creative and innovative task performance?

Data analyses were conducted to obtain insights to answer RQ3 and test its associated hypotheses. The descriptive data from the egg drop task suggested that teams receiving feedback generally had lower TIF and more balanced PER than the control teams. However, the between-sample t-tests conducted on the teams' TIF across both experimental conditions yielded no significant differences for both TIF and PER. This finding did not support hypothesis 3b, which predicted feedback would increase the team's TIF, but somewhat supports hypothesis 3c, which predicted feedback would help balance the team's PER.

However, this finding could be explained by the strong correlations between a team's TIF and PER for the egg drop task, which suggests teams receiving feedback might have chosen to reduce their TIF in attempts to regulate and balance their PER during the egg drop task. This suggestion was further supported by the detailed analyses of individual teams across both conditions for intervals of the egg drop task. The analyses showed during the egg drop task, teams in the feedback condition had considerably more balanced PER than the control teams in the first interval. It also showed that after receiving feedback, teams in the feedback condition showed an even more balanced PER during the second interval of the egg drop task.

Unfortunately, the results revealed a ceiling effect and limitation of the egg drop task to determine the team's creative problem-solving performance. This limited answering the research questions and hypotheses related to the team's creative problem-solving performance (hypothesis 3a). As such, there is a need for a more complex creativity task with a finer discriminative performance measure to be used in future planned studies for this PhD.

Feasibility of using BiT coding system for live verbal behavioural coding

As mentioned, the current study was a pilot study evaluating the feasibility of utilising the BiT coding system for live verbal behavioural coding and analysis. Using the simplified 8-category tally-based system for this study was a deliberate choice, as the observers used in this study required further expert training before they were deemed qualified enough to use the whole 15-category BiT coding system. However, utilising a tally-only coding system without audio and video recordings led to the inability to produce transcripts of the team's interactions.

Transcripts with a sequential behaviour timeline could provide further insights into the team's decision-making processes and verbal behavioural trends during an idea generation and creative problem-solving context. Therefore, it was planned for the observers to complete their training and utilise the 15 BiT Category coding system iPad app accompanied with audio and video recording of participants for future empirical studies planned for this PhD.

The study's environmental setting and results helped establish the viability and proof of concept for using live verbal behavioural coding and providing team dynamics feedback in an educational classroom without major issues. Feedback from participants were positive, and they generally thought that having their team's verbal behaviours and interactions observed was neither obstructive nor intrusive. The participants also welcomed similar interventions or coding schemes as the deeper analyses of their team dynamics would allow them to gain additional knowledge beyond the taught content.

However, conducting the current study and observing teams in a classroom setting might have introduced a confounding variable that potentially impacted the team's dynamics during idea generation and creative problem-solving tasks. The close proximity of the teams within a classroom setting might have resulted in conversations and information shared by other teams influencing and affecting each other, especially those deemed "good ideas". The potential influence and integration of said "good ideas" from the other teams could be why all five

participant teams in the current study had similar vessel designs to complete the egg drop task leading to the ceiling effect present.

Thus, it is recommended that participating teams be tested individually in separate rooms to prevent external influences from affecting their team's dynamics and task performance during subsequent studies planned for this PhD. Testing participant teams in individual rooms will also allow for clear audio and visual recordings, enabling transcripts of the team's interactions to be produced.

Summary

In conclusion, the current study successfully showcased the feasibility of using the BiT coding system to live code a team's dynamics and verbal interactions to produce data required to provide teams with team dynamics feedback. The results and findings also showed the effectiveness of feedback in balancing team verbal interaction patterns, and increased team TIF correlates with a team's GAUT (creativity) score. However, given the current study's small sample size, further studies are needed to establish the relationships between a team's TIF, PER and creative problem-solving performance and how team dynamics feedback would impact said relationships.

It was also acknowledged that limitations in the current methodology prevented further analyses of the teams' creative problem-solving performance and the temporal micro-dynamics of teams. Addressing the methodological limitations above is anticipated to help uncover and provide greater insight into a team's dynamics on their creativity and innovation performance and the effectiveness of team dynamics feedback.

Chapter 5 Bridgebuilding Study

Introduction

The previous study, Study 1 (See Chapter 4) showed the effectiveness of feedback in balancing team verbal interaction patterns and that an increase in team's total interaction frequency (TIF) correlates with a team's creativity performance. It also showcased the feasibility of using the BiT coding system to live code a team's dynamics and verbal interactions without intruding on or obstructing the team. The study demonstrated the ability of the BiT coding system, albeit a simplified version, to produce the data required to provide teams with team dynamics feedback.

Although Study 1 yielded promising results, it also highlighted a few limitations to the methodology that, if addressed, would help obtain further insights to answer the research questions for this PhD. The previous study conducted during a planned academic tutorial saw time constraints limit the Guilford Alternative Uses Test (GAUT) to only one item. Researchers have suggested using two or more things of similar difficulty levels during the GAUT to obtain a more accurate measurement of creativity (de Bloom et al., 2014; Runco & Acar, 2012). Hence, future studies planned for this PhD should administer at least two items for the GAUT to address this limitation.

Second, results from the previous study found a ceiling effect within the creative problem-solving task used during the study. This resulted in the inability to test hypotheses and answer the research questions related to the team's creative problem-solving performance. Hence, a better creative problem-solving task that can provide an infinite and precise measurement of the team's performance should be used within the subsequent empirical studies planned for this PhD.

Third, the previous study lacked audio-video recordings of the team interactions during the idea generation and creative problem-solving tasks. This led to the limitation in producing transcripts of the team's interactions and obtaining a sequential timeline of verbal behaviours exhibited. Having a team's transcript with a sequential behaviour timeline could provide further

insights and contexts into the team's decision-making processes and verbal behavioural trends during an idea-generation and creative problem-solving context.

In this current study, we conducted a modified replication of Study 1 on a larger scale that addressed all the abovementioned limitations. The current study was designed to provide more evidence and insights into using the 15-category BiT Coding iPad app to live code the verbal interactions of teams. The data obtained from this study using an improved methodology would also help validate the findings of Study 1 and provide further insights to answer the research questions below:

RQ1: How does a team's dynamics impact their creativity and innovation?

a. A team's TIF is significantly positively related to the team's creativity and innovation.
b. A team's PER is significantly inversely related to the team's creativity and innovation.

RQ2: What verbal behaviours affect a team's creativity and innovation?

RQ3: Does immediate communication profile feedback improve future team dynamics and creative and innovative task performance?

a. Teams receiving feedback would have better task performance.
b. Teams receiving feedback would have increased TIF.
c. Teams receiving feedback would have a more balanced PER.

However, it should be noted that this study was conducted at the start of the COVID-19 pandemic in early 2020. The pandemic declaration led to social distancing measures and subsequent lockdowns, which restricted and suspended many face-to-face (F2F) activities. The lockdowns resulted in the data collection for this study being halted halfway through due to the

study's methodology's face-to-face nature. Nevertheless, the methods used in the study (before data collection was suspended) are described in the following section.

Methods

Participants

A total of 43 first-year undergraduate students (20 females and 3 males) aged 18 to 38 (M = 18.74, SD = 1.84) from Edge Hill University were recruited to participate in the study. This provided a total of 10 participant teams of four to five members. The participant teams recruited for this study all had at least eight continuous weeks of experience working together on academic projects.

Participants were not compensated for participating in this study, and it was emphasized that participation status did not affect their academic grades to prevent feelings of coercion. All participants were also explicitly reminded that they would be audio and video recorded during the experimental tasks. The study received ethical approval from Edge Hill University's Psychology Department's Research Ethics Committee (Ref: BT/03-2019/064). All protocols for obtaining informed consent, GDPR and Debriefing were adhered to (See Appendix F for ethics forms).

Materials

Team Idea Generation: Guilford's Alternative uses task (GAUT)

The Guilford Alternative Uses Tests (GAUT) developed from Guilford's (1967) Structure of Intellect were used to measure the team's idea generation performance. The most common example of this test was "*Please list all the uses you can think of for a brick/pen.*" (de Bloom et al., 2014; Runco & Acar, 2012).

Similar and related uses were not counted to prevent inflation of scores, an example being "*boiling an egg*", "*scrambled eggs*", and "*omelette*" is classified as cooking an egg and tallied as one valid use; however, "*making a meringue*" or "*baking cakes*" would count for two different valid entries. The teams would be given two items during the task to generate uses: a

brick and a pen. Each team was given 5 minutes to generate uses for each item. The combined final tallied scores for both items were used as their team's idea generation performance.

Team creative problem-solving task: Bridgebuilding task

A classic bridgebuilding task was used to measure the team's creative problem-solving performance. Educators and workshops have used variations of the bridgebuilding task to teach team working and creativity skills (Freiermuth, 2002; Kang et al., 2011). The task required the participant teams to design and build the longest freestanding bridge across two points from a given set of materials.

The participant teams were each given 30 minutes and the following materials to build their bridge: One roll of scotch tape, two pairs of scissors and a box of plastic straws (each straw is 20 cm long when stretched). Pilot studies showed that the choice of materials above would allow for a wide range of approaches and performance levels for the given task.

Table 5-1 Points allocation for the length of the team's bridge span in cm

Bridge Span Length (cm)	Points awarded
160.00 cm and above	+10
145.00 - 159.99 cm	+9
130.00 - 144.99 cm	+8
115.00 - 129.99 cm	+7
100.00 - 114.99 cm	+6*
85.00 -99.99 cm	+5
70.00 - 84.99 cm	+4
55.00 -69.99 cm	+3
40.00 - 54.99 cm	+2
25.00 -39.99 cm	+1
24.99 cm and below	+0

* If bridges fail the task requirements, the maximum points awarded is capped at 6 points regardless of the total length of their bridge span

The team's performance was judged by measuring their bridge span's total length (cm) across the two points. The team failed the task if their bridge could not stay upright, collapsed in the middle, was supported by other materials, or was taped to any surface for additional support. The length of the bridge span in cm corresponded with the number of points awarded using the following scoring table (Table 5-1). The teams whose bridges failed the task requirements listed above would receive a maximum of 6 points, irrespective of the total length of their bridge.

Measuring team dynamics: BiT Coding

The verbal behaviours exhibited by the teams during the study were coded by trained observers using the 15-category Behaviour in Teams (BiT) coding system (Farley et al., 2018; Rackham & Morgan, 1977) app developed for the iPad. The live-coded verbal behaviours summarise the team's interactions and are used to obtain the team's total interaction frequency (TIF) and participation equity rate (PER). The 15 categories of the BiT coding system (Farley et al., 2018) are listed below in its four meta-categories (see Table 5-2), with descriptions for each category found in Appendix A.

Table 5-2. The 15 BiT coding verbal behaviours, divided into their four meta categories

Initiating	Reacting	Clarifying	Balancing/Process
1. Proposing Procedures	4. Supporting Ideas	8. Checking Understanding	13. Shutting Out
2. Proposing Ideas	5. Supporting People	9. Seeking Task Information	14. Bringing in
3. Building	6. Disagreeing	10. Seeking Personal Information	15. Lightening the Mood
	7. Defending/ Attacking	11. Giving Task Information	
		12. Giving Personal Information	

BiT Observer Training

Observers (coders) wanting to utilise the BiT coding system require specialist training to ensure objective and accurate coding of verbal behaviours with high inter-rater reliability (Farley et al., 2018). The training for the observers consisted of two parts, the first being a video-based learning course found on the iPad app version of the BiT coding system, followed by a facilitator-led training session. The video-based training required observers to watch pre-recorded videos introducing the 15 categories in sequence and practice coding the various categories using pre-recorded audio tapes provided in the BiT iPad app. Observers needed to pass the video-based training session before attending the facilitator-led training session to live-code simulated live team meetings.

The observers' coding accuracy was monitored throughout the training via a Cohen's kappa value at the end of each simulated audio tape or mock coding session. The Cohen's Kappa value was derived by comparing the observers' codes against the answer key in the BiT iPad app or provided by the facilitator during their training session. Observers passed the training course when their Cohen Kappa score on the final test given by the facilitator was equal to or higher than k =.85.

Obtaining a team's TIF and PER

The coded tallies of verbal behaviours the team and individual members exhibited for each task session provided the team's TIF and PER. The total frequencies of verbal behaviours measured would indicate the team's TIF, with higher totals signalling that the team interacted and communicated more. The team's standard deviation (SD) of verbal behaviours frequencies would indicate the team's PER. The SD represents the scatter of verbal behavioural frequencies across the individual team members.

An SD closer to 0 indicates that the team have a similar and almost equal distribution of verbal interactions with each other, whilst a high SD suggests imbalanced participation equity. Regardless of the potential possibilities, a high SD typically signals an issue with a team's dynamics and communication that might subsequently affect a team's performance and effectiveness (Cauwelier, 2019; Duhigg, 2016; Google, 2015). This method of scoring and analysing the coded data is similar to the approach used by previous studies measuring a team's PER (Cauwelier, 2019; Duhigg, 2016; Google, 2015; Samrose et al., 2018).

Providing teams feedback

As part of BiT coding training, observers were taught how to utilise the data analyses generated at the end of a session to provide teams with immediate feedback about their team dynamics. Observers provided feedback to the teams using the steps listed below:

1. Observers showed and described the summary of the team's coded verbal behaviours and patterns.
2. The team was given opportunities to ask questions about each behavioural category and its meaning.
3. Observers asked the team what they felt about their interaction patterns and what they thought about the feedback given.
4. Observers concluded the feedback session by asking the team to note if changes were to be made to their interaction patterns before commencing the session.

The main aim of the feedback was to explicitly show both individuals and the team their interaction patterns and provide time for reflecting on the information provided. The feedback session concluded by letting teams decide if modifications to behaviours were needed to improve their team's interaction patterns and performance. It is noted that the observer's role during the feedback session was to guide the team through a reflection process and avoid

making the feedback process elicit biases towards the observer's ideal of how a team should communicate.

Design

The current study utilised a two-condition between-subjects design: 1) the Control condition, where teams performed both experimental tasks without receiving feedback, and 2) the Feedback condition, where teams received feedback about their team's interaction patterns at specific intervals. Figure 5-1 is a flowchart of the entire experimental flow and intervals where feedback is provided to the participant teams. Each participant team had a trained observer live coding their verbal interactions and used the data summaries to give feedback to teams in the feedback condition. The researcher audio and video recorded all participant teams while completing both experimental tasks, with recordings stopped while feedback was given. Counterbalancing for the GAUT was done by alternating the item presented first to the participant teams.

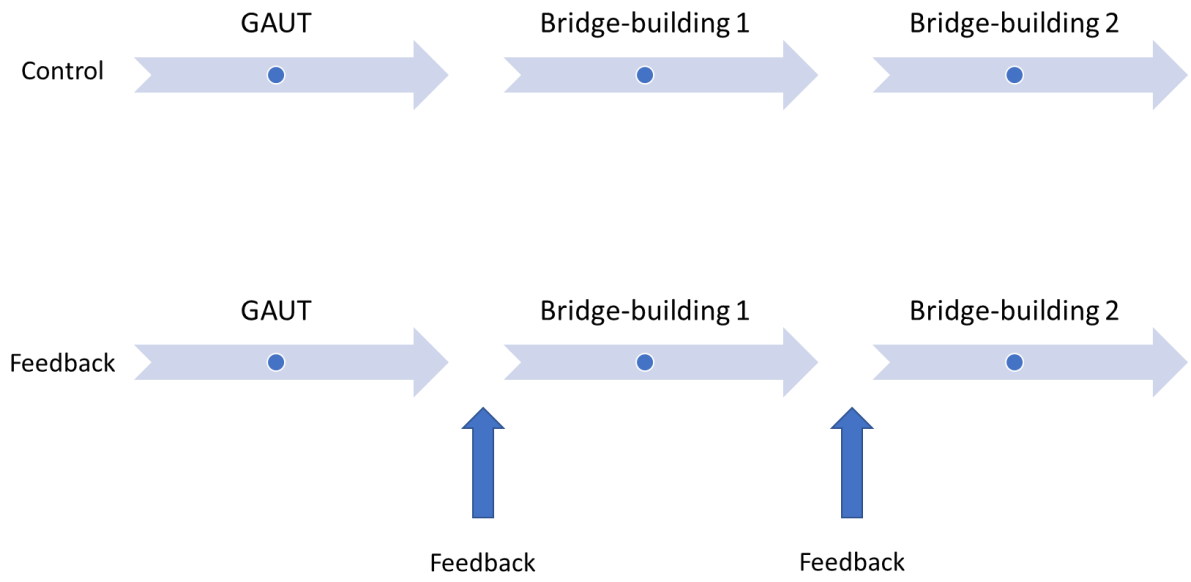


Figure 5-1. Flowchart depicting the entire study design and intervals designated to provide teams with team dynamics feedback

Procedure

Participants were recruited as teams of four to five members and briefed about the study before informed consent was obtained to participate, and be audio and video recorded throughout the tasks. Participant teams were then briefed on the GAUT instructions and given opportunities to ask questions before the task started. Each team was then given 5 minutes to list as many possible, creative and alternative uses for a pen and did the same for a brick. At the end of the GAUT, teams in the feedback condition were given feedback about their team dynamics.

After completing the GAUT, the teams were briefed about the bridgebuilding task instructions, requirements, and scoring system before being allowed to ask questions. The participant teams were given 30 minutes, broken into two 15-minute sessions, to design and build the longest freestanding bridge across two points using the materials provided. After the first 15-minute interval had lapsed, teams in the feedback condition were given feedback about their team dynamics before starting their second 15-minute session.

At the end of the 30 minutes, the bridge span of the team's design was measured using a tape measure, and their length was recorded in cm. After the bridgebuilding task, all participants were asked to complete a basic demographic questionnaire. The entire study took no more than an hour to complete, and participants were debriefed verbally at the end of the study and provided with a debriefing sheet.

Data analyses

Correlational analyses were conducted on the collected data of the team's TIF, PER, meta and individual BiT behaviour category tallies, and task performance scores for the GAUT and bridgebuilding tasks. The analyses would provide further insights to help answer RQ1 (How does a team's dynamics impact their creativity and innovation?) and its associated hypotheses, namely:

a. A team's TIF are significantly related to the team's creativity and innovation.

b. A team's PER is significantly related to the team's creativity and innovation.

Further correlational analyses of the individual behaviour category tallies would also provide insights to help answer RQ2 (What verbal behaviours affect a team's creativity and innovation?).

Two series of between-sample t-tests were conducted to investigate the effects of providing teams feedback on their team dynamics on subsequent task performance and team dynamics. The first set compared the effect of feedback on the team's overall TIF, PER and task performance data of the bridgebuilding task for both experimental conditions. The second set compared the impact of feedback on the team's TIF and PER within each half of the bridgebuilding task. The analyses would provide further insights to help answer RQ3 (Does immediate communication profile feedback improve future team dynamics, creativity and innovation performance?) and its associated hypotheses, namely:

a. Teams receiving feedback would have better task performance.
b. Teams receiving feedback would have increased TIF.
c. Teams receiving feedback would have a more balanced PER.

Results

As mentioned, the Covid-19 pandemic and subsequent lockdowns only saw the data of 10 participant teams being successfully collected before the forced termination of data collection for this study. A K-S test for normality indicated normal distributions for all the collated data measures for the current study.

The results will be divided into three subsections. The first section analysed the teams' collated data for the GAUT and tested for a team's dynamics and their GAUT score. The second section analyses the team's collated data for the bridgebuilding task and tests for significant correlations between a team's dynamics and their Bridge Building Task performance. The third section tests the effectiveness of feedback on the team's dynamics and performance across both experimental conditions.

GAUT data analyses

TIF and PER on GAUT performance

Pearson correlation analyses were conducted to test for significant relationships between a team's TIF (*M* = 107.50, *SD* = 16.49) and PER (*M* = 12.08, *SD* = 5.64) with their GAUT score (*M* = 35.80, *SD* = 7.00). The results showed a strong negative significant negative correlation between a team's TIF and their GAUT score, *r* = -.85, *p* =. 002 and a negative non-significant correlation between a team's PER and their GAUT score, *r* = -.20, *p* = .583. A non-significant positive correlation was also found between the team's TIF and PER, *r* = .57, *p* = .087. The descriptive data and correlations for the GAUT are shown in Table 5-3.

Table 5-3. Descriptive statistics and correlations of the team's recorded frequencies for TIF, PER and ideas generated

	Mean	SD	1	2	3
1. TIF	107.50	16.49	-		
2. PER	12.08	5.64	.57	-	
3. GAUT score	35.80	7.00	-.85*	-.20	-

Individual BiT behaviour categories on GAUT performance

Pearson correlation analyses were conducted to test for significant relationships between a team's frequency tally of the four meta BiT behaviour categories on their GAUT scores. The results indicated a significant negative correlation between a team's frequencies of 'Clarifying' verbal behaviours on their GAUT scores, *r* = -.83, *p* = .003. There were no significant correlations between a team's tally of 'Reacting' (*r* = -.63, *p* =.051), 'Initiating' (*r* = .09, *p* = .911) and 'Balancing' (*r* = -.19, *p* = .599) verbal behaviours on their team's GAUT scores. The descriptive statistics and correlation matrix are in Table 5-4 below.

Table 5-4.Descriptive statistics and correlations of the team's recorded frequencies for the four meta-BiT verbal behaviour categories and GAUT performance

	Mean	SD	1	2	3	4	5
1. Initiating	58.50	7.03	-				
2. Reacting	17.80	9.40	.20	-			
3. Clarifying	20.80	8.02	-.23	.41	-		
4. Balancing	10.40	9.20	-.38	-.40	.18	-	
5. Ideas generated	35.80	7.00	.09	-.63	-.83**	-.17	-

*. Correlation is significant at the < .05 level (2-tailed)

**. Correlation is significant at the < .01 level (2-tailed)

Further Pearson correlation analyses were conducted to test for significant relationships between the teams' tallies of 15 BiT behaviour categories with their GAUT score. The results indicated that increasing a team's frequency of 'Proposing ideas' had a strong positive significant correlation with their GAUT performance (r = .73, p = .017). The results also indicated increasing team members' frequencies of 'Supporting ideas' (r = -.66, p = .036), 'Checking Understanding' (r = -.79, p = .006) and 'Giving task info' (r = -.75, p = .013) had strong negative significant correlations with their GAUT performance.

There were non-significant negative correlations between a team's frequencies of 'Proposing Procedures' (r = -.38, p = .277), 'Building' (r = -.56, p = .089) and 'Giving personal information' (r = -.30, p = .398) with their GAUT performance. There was also a non-significant strong positive correlation between a team's frequencies of 'Supporting people' (r = .50, p = .145) and their GAUT performance. The full correlation matrix can be found in Table 5-11 at the end of this chapter.

Bridgebuilding data analyses

TIF and PER on bridgebuilding performance

Table 5-5. Descriptive statistics and correlations of the team's recorded frequencies for TIF, PER and bridgebuilding task performance.

	Mean	SD	1	2	3
1. TIF	210.70	34.24	-		
2. PER	17.80	5.51	-.03	-	
3. Bridgebuilding task score	5.70	2.21	.23	-.53	-

Pearson correlation analyses were conducted to test for significant relationships between a team's TIF and PER on their bridgebuilding task performance. The results showed a non-significant positive correlation between a team's TIF and bridgebuilding task performance, r = .23, p =.517. The results also indicated a negative non-significant correlation between a team's PER and their bridgebuilding task performance, r = -.53, p = .114. The descriptive data and correlations are in Table 5-5.

Individual BiT behaviour categories on bridgebuilding performance

Table 5-6 Descriptive statistics and correlations of the team's recorded frequencies for the four meta-BiT verbal behaviour categories and bridgebuilding performance

	Mean	SD	1	2	3	4	5
1. Initiating	50.20	9.10	-				
2. Reacting	20.40	7.76	.42	-			
3. Clarifying	98.40	18.73	.40	.32	-		
4. Balancing	78.10	21.36	.20	.43	-.11	-	
5. Bridgebuilding task performance	5.70	2.21	.62	.07	.01	.31	-

Pearson correlation analyses were also conducted to test for significant relationships between the teams' frequencies of the four meta BiT behaviour categories on their bridgebuilding performances. The results indicated no significant correlations between a team's frequency of

'Initiating' (r = .62, p = .058), 'Reacting' (r = .07, p = .856), 'Clarifying' (r = .01, p = .975), and 'Balancing' (r = .31, p = .386) behaviours on the team's bridge building task performance. The descriptive data and correlations are in Table 5-6.

Pearson correlation analyses were conducted to check for significant correlations between the team's frequencies of the individual 15 BiT verbal behaviour categories on their bridgebuilding task performances. The results indicated non-significant positive correlations between the team's frequencies of 'Proposing procedures' (r = .46, p = .179), 'Proposing ideas' (r = .38, p = .275), 'Building' (r = .25, p = .483), 'Supporting ideas' (r = .34, p = .337), 'Seeking task information' (r = .21, p = .553) and 'Bringing in' (r = .21, p = .567) verbal behaviours on their task performance.

The results also indicated non-significant negative correlations between a team's frequencies of 'Disagreeing (r = -.47, p = .176) and 'Seeking personal information' (r = -.24, p = .502) verbal behaviours on their bridgebuilding task performance. The correlation matrix for this analysis can be found in Table 5-12 at the end of this chapter.

Effectiveness of Feedback analyses

The descriptive data of the team's overall TIF, PER and team bridgebuilding task performance across both experimental conditions are shown in Table 5-7. Between-subject t-tests were conducted to test for significant differences in the team's TIF, PER and bridgebuilding task performance across both experimental conditions. The results indicated marginally insignificant differences between the bridgebuilding task performance of control and feedback teams, $t(8) = 2.25$, p = .055. The results also showed a significant difference in the team's PER, [$t(8) = -2.98$, p = .018] but found no significant differences in the teams' TIF [$t(8) = 0.45$, p = .665] exhibited during the bridgebuilding task.

Table 5-7. Mean and SD of the combined team's TIF, PER and bridgebuilding task performance score.

Condition/Variable	TIF		PER		Bridgebuilding task performance	
	Mean	SD	Mean	SD	Mean	SD
Control	205.60	45.81	21.59	2.54	4.60	1.67
Feedback	215.80	21.80	14.01	5.10	6.80	2.28

Between-sample t-tests were used to test for significant differences in the team's TIF and PER between experimental conditions for each half of the bridgebuilding task (see Table 5-8). The results indicated no significant differences between the teams' TIF [$t(8) = .76$, $p = .467$] and PER [$t(8) = -1.80$, $p = .110$] in the first half of the bridgebuilding task. The results also indicated no significant differences between the teams' TIF [$t(8) = -.98$, $p = .358$] and PER [$t(8) = -2.02$, $p = .078$] for the second half of the bridgebuilding task.

Table 5-8. Mean and SD of team's TIF and PER for both experimental conditions during both halves of the bridgebuilding task.

Condition/Variable	1st half		2nd half	
	TIF	PER	TIF	PER
Control	162.20	17.55	43.40	4.38
Feedback	176.20	13.30	36.20	2.86

Discussion

The current study had three main aims: 1) to obtain further insights into the relationships between team dynamics and their creativity and innovation performance, 2) to evaluate the effectiveness of team dynamics feedback to improve a team's subsequent task dynamics and

performances, and 3) to validate the findings of the previous study (see Chapter 4). The following sections will discuss how the results section achieved the aims above and answer the research questions and their associated hypotheses for this study.

GAUT analyses

The current study indicated a significant negative correlation between a team's TIF and creativity performance which did not support hypothesis 1a, that suggested teams with a higher total number of interactions would have better team creativity scores due to more information exchange. The current findings thus contradict those of the previous study (see chapter 4) and the literature review (Bui et al., 2019; Marlow et al., 2018). Further analysis of the 4 meta BiT categories showed large negative correlations between a team's 'Reacting' and 'Clarifying' behaviours on their GAUT scores. Given that the TIF is made up of the frequencies of all four meta BiT categories, it could have contributed to the significant negative correlations between the teams' TIF and GAUT scores. This finding also supports previous calls for research to move beyond the number of verbal exchanges and evaluate the quality of team interactions (Marlow et al., 2018).

Analyses of the individual verbal behaviour categories with the team's GAUT scores revealed multiple categories negatively correlated with the team's GAUT scores. A significant negative correlation was found between a team's 'Checking understanding' behaviours and their GAUT scores. Reviewing the recordings and transcripts showed most statements in this category involved team members clarifying task requirements or the appropriateness of their answers. The transcripts (see Appendix B for a full example) also showed a trend where 'Seeking task information' behaviours typically lead to information being provided by other members which subsequently sees them check their understanding of the provided information. These

exchanges about task requirements or answers' appropriateness reduced the time the teams had to generate ideas and could explain the current findings.

The transcripts (see Appendix B for a full example) also suggested most participant teams started the GAUT without fully understanding the task requirements. This highlights the importance of ensuring all team members understand the task's requirements and parameters before starting. Teams could then spend more time focusing on completing their given task instead of utilising it to brief their team members about its nature and requirements, especially those with a short time limit.

The team's frequency of 'Proposing ideas' correlated positively with their GAUT score, which was expected given that the GAUT requires teams to propose as many ideas as possible. The transcripts indicated a trend that generally sees the verbal behaviours to follow it either: 1) support/praise the proposed idea or the individual who proposed it ('Supporting idea'), 2) jokes or humorous interjections about the proposed idea ('Lightening the mood'), or 3) building upon the initial idea to propose a new one which may lead to further repetitions of the behaviours above ('Building').

These behaviours, as mentioned in the literature review (see Chapter 2), are beneficial towards team cohesion, creativity and idea generation, and the current findings see them leading to more communication and ideas being generated (Hülsheger et al., 2009; Marlow et al., 2018). However, the correlational analyses indicate that excessive 'Building' and 'Supporting ideas' or 'Lightening the mood' with jokes reduces the team's performance. It is, therefore, essential for teams to review the quality of their interactions and to stay task-focused (Marlow et al., 2018). Given its qualities, the GAUT could be used as an ice-breaker activity to encourage further team bonding during the initial phases of team formation, as it could help promote the interaction of team members and build team cohesion.

With regards to PER, the non-significant inverse correlation between the team's PER and their GAUT performance indicated balancing a team's PER improved their creativity. These findings supported hypothesis 1b positing a more balanced team PER improved team creativity (idea generation) performance and are consistent with previous research findings (Duhigg, 2016; Google, 2015). However, it does contradict the previous study's findings, which saw more imbalanced team PER correlating with better team GAUT performances. The change of items used in the GAUT (egg to pen and brick) and the increased number of GAUT iterations (1 to 2) from the previous study could have affected the relationships. The testing environment from a packed classroom to an isolated dedicated testing room could have also impacted the relationships between team dynamics and creativity.

The literature review supports this (see Chapter 2) and suggests a change in environment, context, or tasks might see a difference in the direction of the relationships between factors related to creativity (Li et al., 2018; Pisani, 2012; Stahl et al., 2010; Thatcher & Patel, 2011; Warner et al., 2012; Zoltan, 2015). As such, the current findings suggest that further studies should obtain additional insights regarding the impacts of environmental factors on a team's dynamics and creativity using the same tasks as the current study's methodology.

Bridgebuilding task

The analyses for the bridgebuilding task found that increased TIF and more balanced PER correlated with better team performance, albeit non-significant. These findings supported hypotheses 1a and b, and previous research positing that increased TIF and balanced PER positively correlate with a team's creative problem-solving performance. The four meta BiT categories analyses showed that 'Initiating' and 'Balancing' behaviours had non-significant positive correlations with the team's bridgebuilding task performance.

The detailed analyses of the 15 behaviour categories on the team's bridgebuilding performance yielded no significant correlation. However, it showed that increased frequencies of 'Proposing' and 'Building upon procedures/ideas' and 'Supporting/praising' teammates benefited a team's creative problem-solving performance. Teams that performed well during the task discussed and chose their design which was well understood by all team members and thus led to a better-made bridge prototype.

Further review of the transcripts (see Appendix C for a full example) and recordings showed that after an idea or procedure was proposed, the team would provide opinions about it, leading to further interactions. These interactions could support, clarify, disagree or even be humourous, leading to a decision on the initial idea or procedure before repeating this cycle (see Table 5-9). This finding suggests the importance of obtaining the opinions and thoughts of the other team members as it could improve their decision-making, both hallmark traits of effective and innovative teams (Duhigg, 2016; Google, 2015). Although teams exhibited clarification behaviours, they mainly comprised precise questions related to the bridge design, not the task itself (See Table 5-9 for an example). This highlighted the importance of ensuring all team members were clear on the task requirements and parameters, which would encourage active contributions and performances.

Table 5-9. Example of a transcript of a live-coded team during the Bridgebuilding task

Participant	Content	Behaviour
004	So, we are going to tape those together and it goes on top	Proposing Idea
003	Yeah	Supporting idea
004	And then going to build more layers…	Building
003	Shall we tape them together then?	Checking Understanding

005	I just feel like everyone should look at some kids videos as we might get some ideas for it.	Proposing procedure
004	Nah….	Disagreement
001	Well…. (might work) for you…	Lightenening the mood
002	What if… just…. if we talk about this, I mean you just never try to be bob the builder do you?	Proposing procedure
004	I mean it depends…. what kind of job has to do with straws.	Building
002	Never mind straws, I was never a good at Lego…	Giving personal information
005	I never ever had a Lego set bought for me.	Giving personal information
004	You both had a troubled childhood….	Lightening the Mood
002	I was ok…. With Lego… I was ok… it was just a joke…	Giving personal information

The analyses also revealed that 'Disagreeing' negatively affected the team's creative problem-solving performance. The transcripts found that teams usually had disagreements during the ideation process. However, this typically led to the team members spending more time clarifying the idea design rather than making progress on refining and obtaining a "breakthrough" on their existing ideas. Due to time constraints, this often resulted in an "incomplete" discussion at the end of the task and a loss of momentum, which saw the team following the initial idea proposed or, to quote a participant, "*wing the design of the bridge now*" (See Table 5-10).

Table 5-10. Transcript of the same live-coded team above later during the task.

Participant	Content	Behaviour
003	This is not…. (what I proposed)	Giving Personal Information

002	Sorry I was trying to make a good bridge… not this….	Disagreeing
001	It still not very long though is it.	Giving Task information
004	It doesn't have to be long	Giving Task Information
001	It does!	Disagreeing
004	This is one way to even decide who is our leader for the xxxxxx project (academic team assignment) to just like create something….	Lightening the mood
003	It doesn't even need to be nice as well	Lightening the mood
002	How much time do we have?	Seeking Task Information
004	Minute and a half	Giving Task information
002	C'mon quick, quick quick	Proposing Procedure
003	We have to wing the design of the bridge now	Proposing Idea
005	This this this is a disaster….	Giving Personal information
002	No this is not a disaster shut up....	Disagreeing

The video recordings and transcripts also highlighted a limitation regarding the current experimental design, which sees feedback occurring halfway through the bridge-building task. Most teams had the majority of their interactions during the first half of the task, whilst little to no interactions were made during the second half as the teams were focused on completing their bridge construction. It is recommended to measure the team's dynamics for the entire duration of a task iteration and provide feedback before the commencement of the next iteration.

Effectiveness of BiT Coding system and feedback

During this study, the 15-category BiT coding system and app proved to be a user-friendly and intuitive tool to accurately code a team's interactions and measure their team's dynamics in real time. The current study successfully showcased the BiT Coding iPad app's ability to

immediately generate the data summaries of a team's dynamics post-session. The data summaries were then used to provide teams feedback about their dynamics before the subsequent session started. The effectiveness of giving teams feedback about their dynamics is discussed below.

The average performance levels of the feedback teams were better than the control teams, with the t-test results being marginally insignificant. This finding supported hypothesis 3a, which suggested providing feedback on team dynamics would improve the team's performance. The descriptive data also showed that teams in the feedback condition did have higher TIF averages than the control teams. However, the t-test analyses did not support hypothesis 3b, which suggested giving team dynamics feedback would significantly increase a team's TIF. The descriptive data and t-test analyses show that providing teams receiving feedback had significantly more balanced PER and supports hypotheses 3c.

The observer notes indicated teams receiving feedback mainly focused on the information regarding their distribution of interactions (PER) rather than the TIF. The teams' lack of attention to the TIF during the feedback session could explain the minor changes in overall TIF between teams in both experimental conditions. The main aim of the feedback session was to provide the teams with an analysis of their team dynamics to let them develop an actionable plan without input from the observer. Given the team's focus on their PER, it was unsurprising that the team's action plan would mainly focus on obtaining a more balanced PER rather than improving both TIF and PER, which explains the current findings.

The individual analyses of both halves of the bridgebuilding task also showed increased TIF and more balanced PER in the feedback teams than in the control teams. The insignificant findings could be explained by the small sample size of ten participant teams which was a direct consequence of the COVID-19 lockdown resulting in the early termination of data

collection. A larger sample size could see more significant results, and future studies could investigate the effects of feedback across time and between the experimental conditions.

Based on this researcher's experience, the previous study's recommendations of coding the teams in separate rooms improved the coder's ability to hear the team members' interactions, leading to better coding accuracy and helping reduce coder fatigue. However, future studies could evaluate coders' accuracy between an open environment (e.g., a classroom) and a closed environment (e.g., a private room). This would help in accounting for environmental factors that might impact a coder's accuracy and fatigue.

Summary

The results and findings showed that the relationship between a team's dynamics and types of verbal behaviours with creativity and innovation could differ based on the context and task requirements. The transcripts and recordings of the teams provided further context and helped identify the trends of verbal behaviours teams exhibited during idea generation and creative problem-solving tasks. The current results and transcripts also suggested that beyond the quantity and equality of verbal interactions, the quality of said interactions was more crucial towards team effectiveness. Providing team dynamics feedback could balance a team's PER and improve task performance.

In conclusion, the current study successfully addressed the limitations of the previous study and also obtained further insights into the team dynamics affecting team idea generation and creative problem-solving. It also showcased the live coding abilities of the 15-category BiT coding iPad app to measure team dynamics accurately and use it to give teams feedback about their dynamics. The COVID-19 pandemic and enforced lockdowns resulted in the early termination of data collection for this study. However, this also provided an opportunity for this PhD's subsequent empirical study to understand further the effects of virtuality on team dynamics and creativity.

Table 5-11 Descriptive statistics and correlations of the team's frequencies of all 15 individual BiT verbal behaviour categories and number of ideas generated

	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Proposing Procedure	0.50	0.71	--															
2. Proposing Idea	36.90	6.97	-.53	--														
3. Building	21.10	8.01	.21	-.55	--													
4. Supporting Idea	16.40	9.99	.28	-.48	.58	--												
5. Supporting People	0.90	1.37	.52	.28	-.24	-.45	--											
6. Disagreeing	0.30	0.48	.49	-.29	.02	-.14	.39	--										
7. Defending/Attacking	0.20	0.63	.25	-.45	.48	-.08	.03	.51	--									
8. Checking Understanding	4.50	3.06	.03	-.48	.41	.41	-.54	-.26	.17	--								
9. Seeking Personal Info.	0.40	0.52	-.30	.01	-.23	-.01	-.57	-.53	-.27	.28	--							
10. Seeking Task Info.	1.30	1.34	.53	.04	-.09	.15	.38	.19	-.34	-.09	.13	--						
11. Giving Personal Info.	11.30	5.66	.07	-.32	.01	.00	-.25	-.16	.29	-.07	.37	-.45	--					
12. Giving Task Info.	3.30	3.06	.64*	-.77**	.63	.76*	-.15	-.07	.08	.37	.06	.27	.26	--				
13. Shutting Out	0.80	1.03	.91**	-.39	.04	.17	.61	.36	.07	-.28	-.25	.53	.16	.58	--			
14. Bringing in	0.60	1.58	.70*	-.04	-.37	-.30	.75*	.47	-.13	-.21	-.19	.70*	-.27	.07	.70*	--		
15. Lightening The Mood	9.00	8.88	.00	-.48	.15	-.39	-.16	.41	.55	.28	.17	-.16	.16	-.06	-.15	.10	--	
16. Ideas generated	35.70	6.98	-.15	.38	-.28	-.20	.43	-.14	-.59	-.69*	-.33	.08	-.25	-.17	.18	.16	-.43	--

* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

Table 5-12 Descriptive statistics and correlations of the team's frequencies of all 15 individual BiT verbal behaviour categories and bridgebuilding task score

	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Proposing Procedure	24.90	6.38	--															
2. Proposing Idea	11.40	4.09	-0.13	--														
3. Building	13.90	4.33	0.34	-.14	--													
4. Supporting Idea	15.20	8.66	0.45	.11	.66*	--												
5. Supporting People	0.90	1.29	0.47	-.29	-.22	-.23	--											
6. Disagreeing	2.10	1.91	-0.17	-.49	-.66*	-.61	.50	--										
7. Defending/Attacking	2.20	4.44	0.13	-.15	-.77**	-.50	.72*	.78**	--									
8. Checking Understanding	9.80	5.59	0.04	.35	.27	.39	-.30	-.14	-.25	--								
9. Seeking Personal Info.	2.50	2.95	-0.32	-.25	.34	-.01	.13	-.15	-.26	-.46	--							
10. Seeking Task Info.	19.80	8.31	0.56	-.30	.52	.42	.10	-.13	-.13	.49	-.35	--						
11. Giving Personal Info.	25.60	6.70	-0.02	-.43	-.64*	-.53	.27	.65*	.55	-.30	-.30	-.11	--					
12. Giving Task Info.	40.70	12.34	0.43	-.59	.84**	.51	.05	-.26	-.51	-.04	.37	.49	-.27	--				
13. Shutting Out	12.10	8.43	0.40	-.50	.71*	.45	-.26	-.28	-.43	.16	.00	.63	-.22	.73*	--			
14. Bringing in	0.20	0.63	0.34	-.21	-.56	-.41	.85**	.72*	.93**	-.18	-.18	-.03	.49	-.30	-.30	--		
15. Lightening The Mood	27.70	20.93	0.25	-.05	-.80**	-.47	.58	.65*	.90**	-.20	-.54	-.07	.72*	-.55	-.44	.83**	--	
16. Bridgebuilding task score	5.70	2.21	0.46	.38	.25	.10	.34	-.46	.02	.05	.09	.21	-.24	-.04	.01	.21	.04	--

* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

Chapter 6 The effects of virtuality on team dynamics and creativity (idea generation)

Introduction

The conflicting findings of Studies 1 & 2 (see Chapters 4 & 5) suggested that the relationships between a team's dynamics on their creativity (idea generation) could differ based on the environmental factors and the task context or requirements. Further reviewing of the team's transcripts and recordings identified trends of verbal behaviours occurred during team idea generation, which could either be beneficial or detrimental to the team's performance if improperly managed. The results also suggested the necessity to look beyond the quantity (TIF) and equality (PER) of verbal interactions into the quality of said interactions and further highlight the importance of having transcripts and recordings of the teams.

Although the findings were promising, the small sample size and incomplete data collection of the previous study due to the COVID-19 pandemic restricted the generalisability of the results. The pandemic and subsequent lockdowns also prevented the progression of initially planned studies that were all a face-toface (F2F) nature. However, it opened the opportunity to understand better the effects of virtuality on a team's dynamics and effectiveness.

During the lockdowns, organisations adopted full remote working models using virtual video conferencing platforms organisations use (e.g., Zoom, Microsoft Teams). There also were assumptions that the platforms' ability to replicate F2F meetings virtually meant applying good F2F practices would facilitate effective virtual team collaborations on these platforms (Belanger et al., 2021; Singh et al., 2021). However, even with the aid of published good practice guidelines derived from previous empirical research, organisations still encountered multiple issues fostering effective virtual team collaborations on these platforms, such as Zoom fatigue and the benefits of camera usage during sessions (Tasir & Al-Dheleai, 2019; Belanger et al., 2021; Brenan, 2020; Morris, 2020; Moses, 2020; Singh et al., 2021; Waizenegger et al., 2020; Wiederhold, 2020).

An explanation for these issues might be the incompatibility of said good practice guidelines with the new virtual video conferencing platforms such as Zoom, Microsoft Teams, currently used in most virtual team collaborations (Nadler, 2020; Wiederhold, 2020). As mentioned, these good practice guidelines were based on previous research investigating the effects of virtuality on team dynamics and effectiveness. However, as mentioned (see Chapter 2), these studies found virtual teams had poorer creativity/innovation and lesser evenly distributed frequencies of interactions amongst team members (Axtell et al., 2004; Barak & Usher, 2019; Fowler, 2014; Golden & Raghuram, 2010).

It is to note that these studies were primarily conducted on online text-based interaction mediums (e.g., fax, telephone, email, blackboard) rather than the new virtual video conferencing platforms such as Zoom or Teams (Gilson et al., 2015; Samrose et al., 2018). The relatively recent development of these platforms explains the relative lack of research investigating factors affecting effective team dynamics and collaborations on these new virtual platforms compared to those studying individual cognitive and logistical elements (Acai et al., 2018; Alexander et al., 2012).

Recent surveys found that workers preferred some virtualisation within their post-pandemic work arrangements (Brenan, 2020), resulting in organisations (e.g., Google, Xerox, Microsoft) retaining and expanding employees' remote working policies. This suggests that remote working and virtual team collaborations on Zoom and Teams are becoming the norm in the post-pandemic workplace and highlights the importance of understanding the effects of virtuality and camera usage on a team's dynamics and effectiveness. The inconsistent findings from the previous studies and literature review on the impact of virtuality on team dynamics and creativity led to the following research questions and associated hypotheses to be explored within this study:

1) How does a team's dynamics impact their creativity and innovation?

   a. A team's TIF is significantly positively related to the team's creativity.
   b. A team's PER is significantly inversely associated with team creativity.

2) What verbal behaviours affect a team's creativity and innovation?
3) What are the differences in team dynamics and creativity and innovative performance between F2F and online teams?
   a. F2F teams would have higher TIF than virtual teams.
   b. Virtual teams would have more balanced PER.
   c. F2F teams would outperform virtual teams on the same task.
4) Does camera usage impact the dynamics and performance of online team collaborations?
   a. Virtual teams with Cameras on would have higher TIF compared to teams with Cameras off.
   b. Virtual teams with Cameras on would have more balanced PER compared to teams with Cameras off.
   c. Virtual teams with Cameras on would have better creative and innovative task performance compared to teams with Cameras off.

The current study replicated the creativity tasks used (GAUT) in Study 2 virtually. It explored the use of the 15-category BiT coding system to examine the effects of camera usage and virtuality on the relationships between a team's dynamics and creativity. Lockdown restrictions on F2F collaborations during the study's execution saw the use of Study 2's data within the data analyses of this study.

Beyond the theoretical research questions posited above, the current study aimed to provide more evidence and insights regarding the use of the BiT Coding iPad to live code the interactions of virtual teams.

Methods

Participants

A total of 135 undergraduate students (109 females and 26 males) aged 18-38 years old (M = 20.46, SD =5.52) from Edge Hill University's Psychology Department were recruited to participate in the study through the University's Research Participation System (SONA). This provided 32 participant teams consisting of 4-5 members each.

The recruitment criteria required participant teams to email the researcher about any previous experiences working with all the other team members. The participant teams recruited for this study all had at least eight continuous weeks of experience working together on academic projects.

Participants were compensated with either course credits or a cash payment as determined by the rate set by the Edge Hill University's Psychology Department. The study received ethical approval from the University Psychology Department's Research Ethics Committee (Ref: BT/03-2019/064) and all protocols for obtaining informed consent, GDPR and Debriefing were adhered to (See Appendix F).

Materials

Guilford's Alternative uses task (GAUT)

The Guilford Alternative Uses Tests (GAUT) developed from Guilford's (1967) Structure of Intellect was used to measure the team's idea generation performance. The most common example of this test was "*Please list all the uses you can think of for a brick/pen.*" (de Bloom et al., 2014; Runco & Acar, 2012).

Teams were given two five-minute sessions to develop as many possible uses for a brick and a pen. F2F teams recorded their generated ideas on a sheet of A3 paper, whilst virtual teams recorded their answers on a screen-shared Microsoft Office Word document. This helped to ensure consistency in executing the experimental task across all three experimental conditions. The GAUT was scored by reviewing all the named uses for the item given and combining duplicate/similar uses (e.g., using a pen for writing and drawing are similar). After reviewing

both objects, the total number of accepted ideas would reflect the team's overall idea generation performance.

BiT coding system

The verbal behaviours exhibited by the teams during the study were coded by trained observers using the 15-category Behaviour in Teams (BiT) coding system (Farley et al., 2018; Rackham & Morgan, 1977) app developed for the iPad. The live-coded verbal behaviours summarised the team's interactions and were used to obtain the team's TIF and PER. The 15 categories of the BiT coding system (Farley et al., 2018) are listed below in its four meta-categories (see Table 6-1), with descriptions for each category found in Appendix A.

Table 6-1. The 15 BiT coding verbal behaviours divided into their four meta categories

Initiating	Reacting	Clarifying	Balancing/Process
1. Proposing Procedures	4. Supporting Ideas	8. Checking Understanding	13. Shutting Out
2. Proposing Ideas	5. Supporting People	9. Seeking Task Information	14. Bringing in
3. Building	6. Disagreeing	10. Seeking Personal Information	15. Lightening the Mood
	7. Defending/ Attacking	11. Giving Task Information	
		12. Giving Personal Information	

The verbal behaviours exhibited by the team during the GAUT were coded into their respective 15 BiT categories and tallied. Each team would have a total tally of individual behaviours exhibited and a breakdown of the behavioural frequencies of every team member, which provided a team total (TIF) and standard deviation of interaction rates (PER). Higher TIF would suggest teams had more interactions, while low TIF indicated little interaction or communication.

The standard deviation or spread of verbal behavioural frequencies against the team's average indicated the team's PER. A standard deviation closer to 0 indicated that the team had very balanced PERs, whilst higher standard deviations suggested unequal participation equity rates amongst the team members. This replicated the approach Samrose et al. (2018) applied in their study on feedback and PER.

Experimental Design

The current study utilised a between-subjects experimental design with three experimental conditions: 1) F2F: Participant teams performed experimental tasks face to face; 2) Virtual (Cameras on): Participant teams performed the experimental tasks virtually via zoom with their cameras and microphones; and 3) Virtual (Cameras off): Participant teams performed the experimental tasks virtually via zoom only with their microphones active. Counterbalancing was done by alternating the item presented first to the participant teams during the GAUT.

Procedures

F2F teams

The study was conducted face to face with recruited participant teams completing their consent forms after being briefed by the researcher about the study, who explicitly reminded them that they would be audio and video recorded throughout the tasks. Participant teams were then briefed on the GAUT instructions and allowed to ask questions regarding the task.

Each team was then given 5 minutes to list as many possible, creative and alternative uses for a pen and a brick. Alternation of the item presented first to participant teams was done for counterbalancing. After completing the experimental tasks, participants were asked to complete a basic demographic questionnaire. The entire study took no more than 30 minutes to complete, and participants were debriefed verbally at the end of the study and provided with a debriefing sheet.

Virtual teams

The study was conducted virtually on zoom, with recruited participant teams given a Zoom link to join on the day of the study. The researcher briefed participants about the study and explicitly reminded them about being audio and video recorded during the tasks. They then accessed a QR code/weblink to provide informed consent to participate and be recorded throughout the tasks. Participant teams were then briefed on the GAUT instructions and allowed to ask questions regarding the task. Teams in the virtual (Cameras off) condition were then instructed to turn their cameras off for the duration of the GAUT.

Each team was then given 5 minutes to list as many possible, creative and alternative uses for a pen and a brick. Alternation of the item presented first to participant teams was done for counterbalancing. After completing the GAUT, participants were asked to complete a basic demographic questionnaire. The entire study took no more than 30 minutes to complete, and participants were debriefed verbally at the end of the study and provided with a debriefing sheet.

Data analysis

The experimental data from teams in each experimental condition were collated and used in the following analyses to answer the formulated research questions. To answer RQ1, Pearson correlations were conducted to see the relationships between the teams' TIF, PER and the number of ideas generated. Further correlation analyses were conducted between the team's frequencies of the four meta and 15 individual BiT verbal behaviours with their number of generated ideas in general to answer RQ2.

To answer RQ3 and 4, one-way ANOVAs were conducted on the teams' TIF, PER and the number of ideas generated for all three experimental conditions (F2F, Cameras on, & Cameras off). This would help provide further insights about if virtuality led to significant differences in a team's dynamics and idea generation performance.

A final set of Pearson correlations were also conducted between the teams' TIF, PER and the number of ideas generated for each experimental condition. This would provide insights into whether virtuality affected the congruency of the relationships between the team's dynamics on their creativity.

Results

Correlations of team dynamics and idea generation performance (overall)

This section focuses on the correlation analyses between the team's dynamics and exhibited verbal behaviours on their idea generation performance in general. The results indicated that a team's TIF had a significant positive correlation with their GAUT score, $r = .48$, $p = .005$. The team's PER had a non-significant positive correlation with their GAUT score, $r = .31$, $p = .086$. There was a significant positive correlation between a team's TIF and PER, $r = .50$, $p = .004$. The descriptive data and correlation matrix is found in Table 6-2.

Table 6-2. Descriptive data and correlation matrix of the TIF, PER and GAUT score for participant teams in general

	Mean	SD	1	2	3
1. TIF	92.72	32.78	-		
2. PER	10.39	5.64	.50**	-	
3. GAUT score	42.78	14.68	.48**	.31	-

Correlations of BiT behaviour categories and team idea generation performance (overall)

Pearson correlational analyses were conducted between the teams' frequencies of the four BiT meta-categories and their GAUT score. The analyses revealed that a team's frequency of 'Initiating' verbal behaviours had a significant positive correlation with their GAUT score, $r = .79$, $p < .001$. There were no significant correlations between the team's frequency of 'Reacting' ($r = .10$, $p = .570$), 'Clarifying' ($r = -.07$, $p = .703$) and 'Balancing ($r = .28$, $p = .127$) verbal behaviours on their GAUT score. The descriptive data and correlation matrix for this analysis can be found in Table 6-3.

Table 6-3. Descriptive data and correlation matrix of the four BiT meta-categories and GAUT score for participant teams in general

	Mean	SD	1	2	3	4	5
1. Initiating	54.75	16.31	-				
2. Reacting	13.09	11.21	.41*	-			
3. Clarifying	15.41	8.59	.28	.48**	-		
4. Balancing	9.47	8.37	.40*	.25	.41*	-	
5. Ideas generated	42.78	14.68	.79**	.10	-.07	.28	-

Pearson correlation analyses were conducted to check for significant correlations between a team's individual 15 BiT verbal behaviour categories frequencies and their GAUT score in general. The results indicated significant correlations between the team's frequencies of 'Proposing ideas' (r = .95, p = .001) and 'Shutting out' (r = .47, p = .007). The results also indicated non-significant correlations between the team's frequencies of 'Proposing procedures' (r = -.21, p = .259), 'Checking understanding' (r = -.27, p = .140) and 'Seeking task information' (r = .23, p = .201) verbal behaviour with their GAUT score. The correlation matrix for this analysis can be found in Table 6-10 at the end of this chapter.

Effects of virtuality on team dynamics and effectiveness

This section focuses on the data analyses examining the effects of virtuality on team dynamics and idea generation performances. The collated data from the 32 participant teams were used to conduct the data analyses required for hypotheses testing. The descriptive data for the number of ideas generated, TIF and PER by experimental conditions are shown in Table 6-4.

Table 6-4. Descriptive data of the number of ideas generated, TIF, and PER by teams in each experimental condition

	Number of Ideas Generated		TIF		PER	
	Mean	SD	Mean	SD	Mean	SD
F2F	35.70	6.98	107.50	16.49	12.08	5.64

Camera on	48.73	17.34	87.73	32.87	12.70	5.63
Camera Off	43.27	15.29	84.27	41.01	6.55	3.64

Effects of virtuality on team idea generation performance

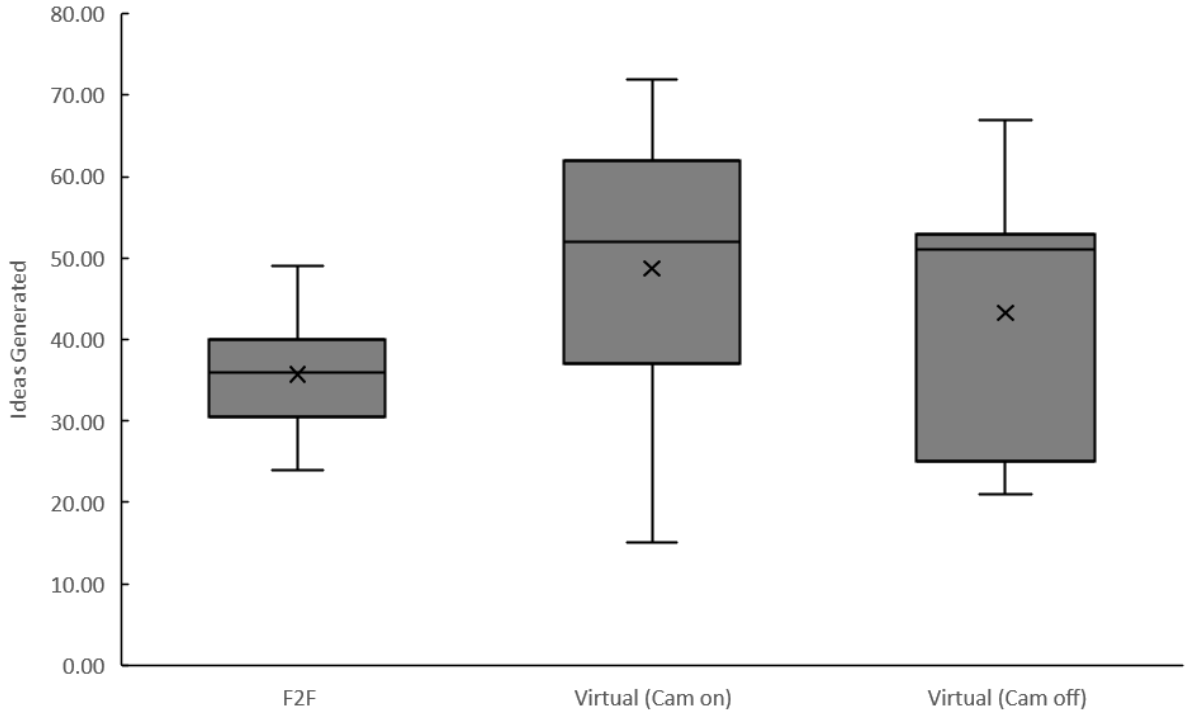


Figure 6-1 *Box plot of the team's idea generation performance for all experimental conditions*

The descriptive data indicate that virtual Cameras on teams had the highest average number of ideas generated (M = 48.73, SD = 17.34), followed by virtual Cameras off teams (M = 43.27, SD = 15.29) and F2F teams having the lowest average of ideas generated (M = 35.70, SD = 6.98). Figure 6-1 is a box plot of the collated data for the teams' idea generation performance. A Levene's test indicated unequal variances within the team's idea generation performance, $F(2, 29) = 4.714$, $p = .017$; hence a Welch one-way ANOVA was used for significance testing between team idea generation performances for all experimental conditions. The results indicated virtuality had marginally insignificant differences in a team's idea generation performances, $F(2, 17.128) = 3.131$, $p = .069$.

Effects of virtuality on team TIF

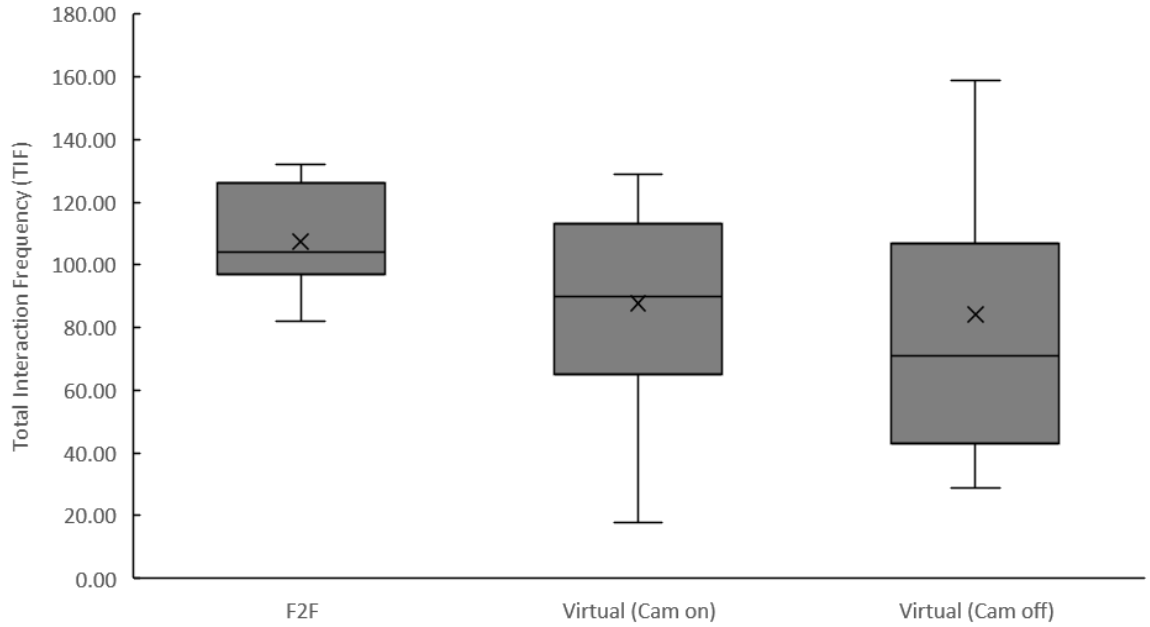


Figure 6-2 Box plot of the team's TIF for all experimental conditions

The descriptive data indicates that F2F teams have the highest average of TIF (M = 107.50, SD = 16.49), followed by virtual teams with Cameras on (M = 87.73, SD = 32.87) and virtual teams with Cameras off having the lowest average of TIF (M = 84.27, SD = 41.01). Figure 6-2 is a box plot of the collated data for the teams' TIF. A Levene's test indicated unequal variances in the team's idea generation performance, $F(2, 29) = 3.867$, p =.032; hence, a Welch one-way ANOVA was conducted to test for significant differences. The results indicated that virtuality had no significant impact on a team's TIF, $F(2, 17.378) = 2.492$, p = .112.

Effects of virtuality on team PER

The descriptive data indicate that virtual teams with Cameras off had the best team participation equity (M = 6.55, SD = 3.64), followed by F2F teams (M= 12.08, SD = 5.64) and virtual teams with Cameras on (M = 12.70, SD = 5.63) having the highest unequal team participation equity. Figure 6-3 is a box plot of the collated data for the teams' PER. A one-way ANOVA was conducted to test for significant differences between team idea generation performances for all experimental conditions. The results indicated virtuality significantly impacted a team's PER, $F(2, 29) = 4.921$, p =.014. A Tukey post hoc test revealed that the PER of virtual Cameras off teams were significantly better than F2F teams (p = .045) and virtual Cameras on teams (p =

.020). There were no significant differences between the PER of F2F and virtual Cameras on teams (p = .958).

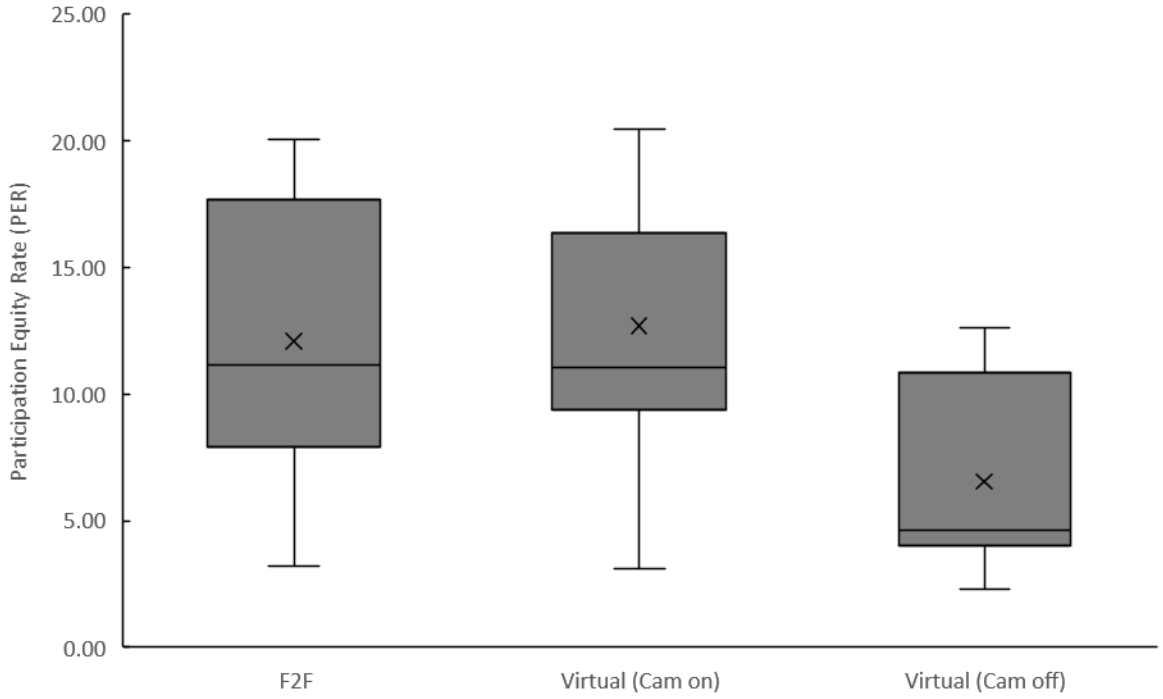


Figure 6-3 Box plot of the team's PER for all experimental conditions

Effect of virtuality on relationships between team dynamics and idea generation performance

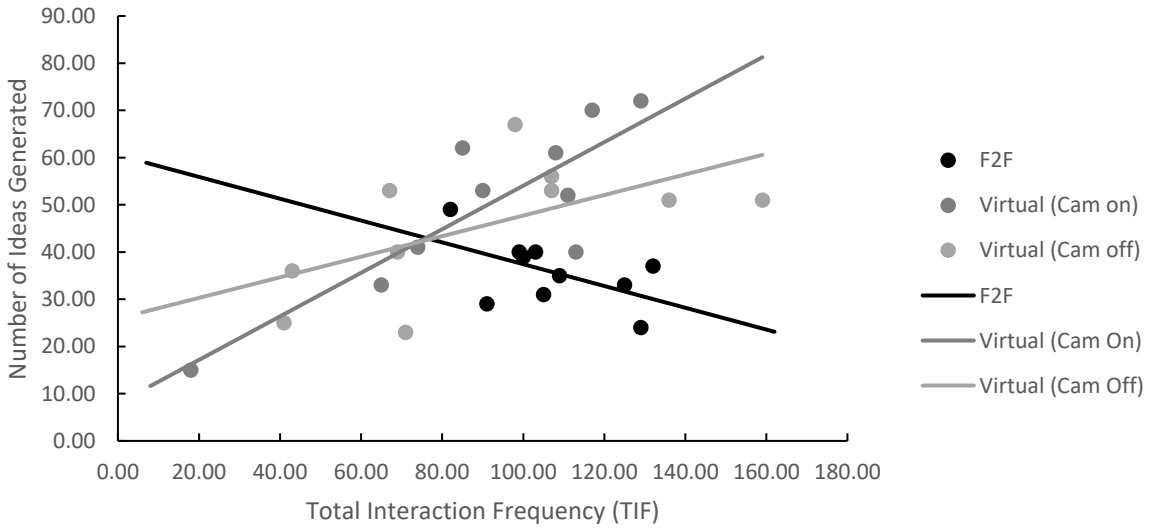


Figure 6-4. Scatterplot and correlation trendlines between the teams' TIF and number of ideas generated based on virtuality.

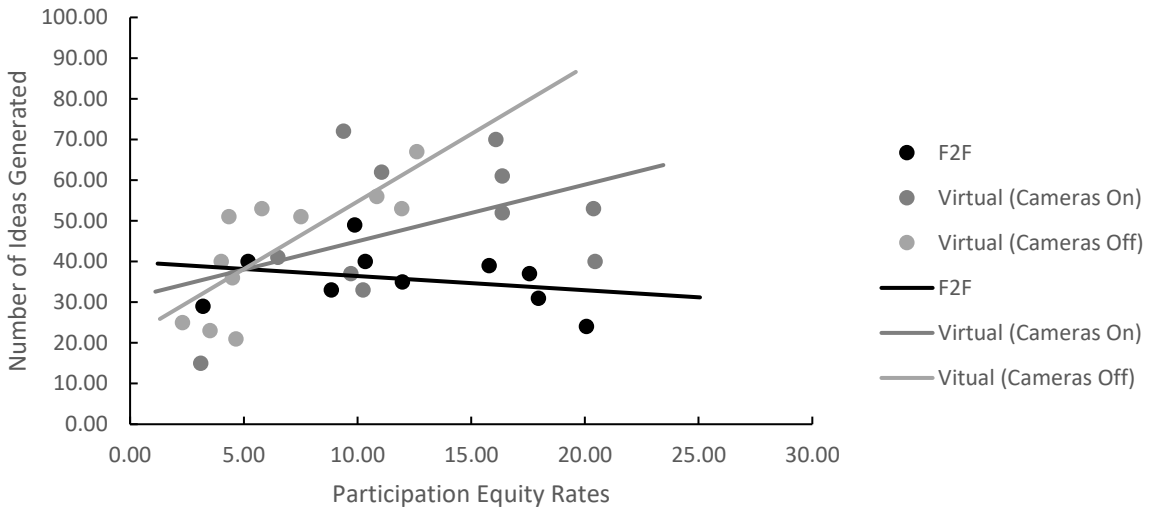


Figure 6-5. Scatterplot and correlation trendlines between the teams' PER and number of ideas generated based on virtuality.

Pearson correlations were conducted between the teams' dynamics (TIF & PER) and idea generation performance for each experimental condition to evaluate the congruency of their associations. Figure 6-4 shows the relationships between a team's TIF with their number of ideas generated during the GAUT across all three experimental conditions. Figure 6-5 shows the relationships between a team's PER with their number of ideas generated during the GAUT across all three experimental conditions. The detailed analyses are reported separately in the following order: 1) F2F, 2) Virtual (Cameras on), and 3) Virtual (Cameras off).

F2F Teams

The results showed a strong negative significant negative correlation between a team's TIF and the total number of ideas generated (r = -.85, p =. 002) and a negative non-significant correlation between a team's PER and their GAUT score (r = -.20, p = .583). A non-significant positive correlation was also found between the team's TIF and PER, r = .57, p = .087. The descriptive data and correlations for the GAUT are shown in Table 6-5.

Table 6-5. Descriptive statistics and correlations of the F2F teams' recorded frequencies for TIF, participation equity and ideas generated

	Mean	SD	1	2	3
1. Total Interactions	107.50	16.49	-		
2. Participation Equity	12.08	5.64	.57	-	
3. GAUT score	35.80	7.00	-.85*	-.20	-

Virtual (Cameras on)

The results showed a significant positive correlation between a team's TIF and the GAUT score (r = .85, p < .001) and a non-significant correlation between a team's PER and their GAUT score (r = .45, p = .163). A significant positive correlation was also found between the team's TIF and PER, r = .68, p = .023. The descriptive data and correlations for the GAUT are shown in Table 6-6.

Table 6-6. Descriptive statistics and correlations of the virtual (cam on) teams' recorded frequencies for TIF, participation equity and ideas generated

	Mean	SD	1	2	3
1. Total Interactions	87.73	32.87	-		
2. Participation Equity	12.70	5.63	.68*	-	
3. GAUT score	48.73	17.34	.85**	.45	-

Virtual (Cameras off)

The results showed a significant positive correlation between a team's TIF and the GAUT score (r = .85, p < .001) and a non-significant correlation between a team's PER and their GAUT score (r = .45, p = .163). A significant positive correlation was also found between the team's TIF and PER, r = .68, p = .023. The descriptive data and correlations for the GAUT are shown in Table 6-7.

Table 6-7. Descriptive statistics and correlations of the virtual (cam off) teams' recorded frequencies for TIF, participation equity and ideas generated

	Mean	SD	1	2	3
1. Total Interactions	84.27	41.01	-		
2. Participation Equity	6.55	3.64	.44	-	
3. GAUT score	43.27	15.29	.68*	.79**	-

Effect of virtuality on relationships between team BiT behaviours and idea generation performance

F2F Teams

Pearson correlation analyses were conducted to test for significant relationships between a team's frequency tally of the four meta BiT behaviour categories on their GAUT scores. The results indicated a significant negative correlation between a team's frequencies of 'Clarifying' verbal behaviours on their GAUT scores, r = -.83, p = .003. There were no significant correlations between a team's tally of 'Reacting' (r = -.63, p =.051), 'Initiating' (r = .09, p = .911) and 'Balancing' (r = -.19, p = .599) verbal behaviours on their team's GAUT scores. The descriptive statistics and correlation matrix are in Table 6-7 below.

Table 6-8.Descriptive statistics and correlations of the team's recorded frequencies for the four meta-BiT verbal behaviour categories and GAUT performance

	Mean	SD	1	2	3	4	5
1. Initiating	58.50	7.03	-				
2. Reacting	17.80	9.40	.20	-			
3. Clarifying	20.80	8.02	-.23	.41	-		
4. Balancing	10.40	9.20	-.38	-.40	.18	-	
5. Ideas generated	35.80	7.00	.09	-.63	-.83**	-.17	-

*. Correlation is significant at the < .05 level (2-tailed)

**. Correlation is significant at the < .01 level (2-tailed)

Further Pearson correlation analyses between the teams' tallies of 15 BiT behaviour categories with their GAUT score indicated increasing a team's frequency of 'Proposing ideas' had a strong positive significant correlation with their GAUT performance, $r = .73$, $p = .017$. The results also indicated increasing team members' frequencies of 'Supporting ideas' ($r = -.66$, $p = .036$), 'Checking understanding' ($r = -.79$, $p = .006$) and 'Giving task info' ($r = -.75$, $p = .013$) had strong negative significant correlations with their GAUT performance. The full correlation matrix can be found in Table 6-11 at the end of this chapter.

Virtual (Camera On)

Pearson correlation analyses were conducted to test for significant relationships between a team's frequency tally of the four meta BiT behaviour categories on their GAUT scores. The results indicated a significant correlation between a team's frequencies of 'Initiating' ($r = .97$, $p < .001$) and 'Balancing' ($r = .70$, $p = .017$) verbal behaviours on their GAUT scores. No significant correlations existed between a team's tally of 'Reacting' ($r = .22$, $p = .509$) and 'Clarifying' ($r = .31$, $p = .353$) verbal behaviours on their team's GAUT scores. The descriptive statistics and correlation matrix are in Table 6-8 below.

Table 6-9.Descriptive statistics and correlations of the team's recorded frequencies for the four meta-BiT verbal behaviour categories and GAUT performance

	Mean	SD	1	2	3	4	5
1. Initiating	55.82	19.52	-				
2. Reacting	7.45	6.07	.42	-			
3. Clarifying	14.82	7.45	.48	.63*	-		
4. Balancing	9.64	7.70	.71*	.07	.29	-	
5. Ideas generated	48.73	17.34	.97**	.22	.31	.70*	-

*. Correlation is significant at the < .05 level (2-tailed)

**. Correlation is significant at the < .01 level (2-tailed)

The analyses on 15 BiT behaviour categories also found that increased frequencies of 'Proposing ideas' (r = .99, p < .001), 'Shutting out' (r = .66, p =.027) and 'Lightening the mood' (r = .62, p = .044) verbal behaviours significantly improved the team's idea generation performance. The full correlation matrix can be found in Table 6-12 at the end of this chapter.

Virtual (Camera Off)

Pearson correlation analyses were conducted to test for significant relationships between a team's frequency tally of the four meta BiT behaviour categories on their GAUT scores. The results indicated a significant correlation between a team's frequencies of 'Initiating' verbal behaviours on their GAUT scores, r = .95, p < .001. There were no significant correlations between a team's tally of 'Reacting' (r = .49, p = .122), 'Clarifying' (r = .02, p = .952) and 'Balancing' (r = .29, p = .394) verbal behaviours on their team's GAUT scores. The descriptive statistics and correlation matrix are in Table 6-9 below. Further analyses on 15 BiT behaviour categories also found that only the team's frequencies of 'Proposing ideas' verbal behaviours had significant correlations with their GAUT score, r = 1.00, p <.001. The full correlation matrix for this analysis is in Table 6-13 at this chapter's end.

Table 6-10. Descriptive statistics and correlations of the team's recorded frequencies for the four meta-BiT verbal behaviour categories and GAUT performance

	Mean	SD	1	2	3	4	5
1. Initiating	50.27	19.02	-				
2. Reacting	14.45	14.63	.60	-			
3. Clarifying	11.09	8.09	.15	.52*	-		
4. Balancing	8.45	8.94	.46	.75**	.74**	-	
5. Ideas generated	43.27	15.29	.95**	.49	.02	.29	-

*. Correlation is significant at the < .05 level (2-tailed)

**. Correlation is significant at the < .01 level (2-tailed)

Discussion

The current study used the BiT Coding iPad app to live code the teams' interactions during the experimental tasks and had three main aims: 1) to obtain further insights into the relationships between team dynamics and their creativity, 2) to understand the effects of virtuality and camera usage have on a team's dynamics and creativity, and 3) to understand how virtuality could affect the relationships between a team's dynamics and creativity. A total of 32 participant teams randomly allocated to three experimental conditions completed two iterations of the GAUT, which allowed comparisons of the team dynamics and creativity between F2F and virtual teams (Cameras on and off). Informed by the findings in Study 2 (see Chapter 5), the current study recorded the participant teams during the GAUT and obtained transcripts that could provide further context regarding the verbal interaction exhibited by the participant teams.

Relationships between team dynamics and creativity (Overall)

The analyses of the overall relationships between the team's dynamics on their creativity suggested a team's TIF had a significant positive correlation with their idea generation performance and accepts hypothesis 1a, which predicts a team's TIF have significant positive correlations with their creativity. This was consistent with previous research findings, showing that increased team interactions resulted in better idea generation performance (Johnson et al., 2000; Li et al., 2018; Pisani, 2012; Warner et al., 2012; Zoltan, 2015).

Turning to PER, the results, although not significant, indicated that an imbalanced team's PER improved the team's creativity and idea generation. This did not support hypothesis 1b and previous literature findings, which predicted a more balanced team PER would correlate with better team creativity (Cauwelier. 2019; Duhigg, 2016; Google, 2015; Samrose et al., 2018). The analyses also showed a significant correlation between the team's TIF and PER, suggesting that increased team interactions naturally increased the imbalance of team member

participation equity. This meant that a more balanced team PER could signal equal participation amongst team members but also indicate a lack of general verbal interaction.

The overall analyses of the four meta BiT categories showed that 'Initiating' behaviours significantly correlated with the team's creativity. 'Balancing' behaviours were also shown to positively benefit the team's creativity, although it is a non-significant relationship. Further analyses indicated a significant positive correlation between the team's 'Proposing ideas' and their GAUT scores, which was expected given it was the main requirement for the GAUT. Unexpectedly was the significant positive correlation between interrupting ('Shutting out') verbal behaviours on the teams' creativity, given its typical negative connations and associations (Samrose et al., 2018).

Table 6-11. Exercept of a coded transcript of a team doing the GAUT

Participant	Content	Behaviour
003	I guess you can stack the pens?	Proposing idea
003	But what will you stack the pens for?	Seeking Task information
001	(laughs)	-
003	Do you know what I am saying?	Checking Undestanding
004	I think I know what she is saying	Giving Personal Information
004	Do you know those felt tip pens where you can stack the covers together?	Building
003	Yeah that is what I am saying	Giving personal information
001/002	Ohhhh….. yeah…..	Supporting idea
003	(simultaneous interruptions) so… to use as a toy that can stack…..?	Shutting out, Building
004	(simultaneous interruptions) so like if you stack them together you can do all kinds of things	Shutting out, Giving Task information

003	What should I write?	Seeking Task Information
004	Hmm… to play with I guess?	Giving Task information
003	You know what I am saying right the type where you have caps similar to this (marker) that can stack	Checking Understanding

The significant positive correlation between the two categories and review of the transcripts and recordings suggested teams proposed or built upon ideas after interrupting an exchange between members (see Table 6-11 and Appendix D for an example). These findings highlight the importance of looking into the context and the quality of said interactions when evaluating team effectiveness.

Effects of Camera usage on Team dynamics and Creativity

The results suggest that camera usage in virtual teams did not significantly impact the team's performance and TIF. This indicates that, at least in short tasks, camera usage did not significantly affect the team's interactions and performance; however, further research using longer tasks and longitudinal research is needed. A significant difference in the PER suggested that virtual teams with their cameras off did not communicate as much. This is supported by the significant correlations between the team's TIF and PER, which were congruent for all three experimental conditions. These findings suggest that increased interactions within a team would naturally increase the imbalance of individual team member participation rates. The scatterplots showed that around half of the virtual teams with their Cameras off had very low TIFs, which could have led to the significantly low PER seen.

Although having similar averages, the variations in the team's TIF across both virtual conditions suggested that some teams interacted more than others. Previous research has shown team diversity factors, such as personality, culture, and gender, to significantly impact team dynamics and information sharing and could explain the current data (Bear & Wolley, 2011;

Bell et al., 2011; Wuchty et al., 2007). Future research could examine the interaction between the factors above and get insights about how they interact with virtuality on a team's dynamics and creativity.

Differences between the team dynamics and creativity of F2F and virtual teams

Although insignificant, the analysis also showed that regardless of camera usage, virtual teams outperformed F2F teams even though they interacted less on average. This was unexpected as previous research findings have suggested virtual teams perform poorer than F2F teams (Axtell et al., 2004; Barak & Usher, 2019; Fowler, 2014; Golden & Raghuram, 2010). The transcripts and recordings showed that F2F teams had more non-task-related verbal exchanges (Chit-Chat), whilst virtual teams were very task focused and did not frequently engage in interpersonal interactions.

This is also supported by the higher number of seeking and giving personal information verbal behaviours and lower number of proposing ideas in F2F teams compared to both virtual team conditions. These combined findings suggest that besides focusing on the team interaction frequencies, evaluating the context and content of team members' verbal interactions is essential as they may differ based on virtuality and be a key factor impacting team idea generation.

The transcripts suggested F2F teams frequently ask members to explain an "uncommon" creative/alternative use for the specified item (e.g., using a pen as a fishing rod or boat paddle). This would lead to non-task related "Chit-Chat" and sharing personal experiences or the cracking of jokes, evidenced by the higher average of lightening the mood behaviours. The transcripts for the virtual (Cameras on) teams revealed similar periods where team members checked their understanding of recently generated ideas because of the "uncommon"

creative/alternative use for the specified item. However, unlike F2F teams, this mainly was followed up with praise for the individual but with very little “chit-chat” following that.

The transcripts for virtual (Cameras off) teams revealed that their verbal and behavioural sequences were generally very short and had little to no interpersonal “Chit-Chat” and fewer jokes. This finding suggests that although virtual video conferencing platforms can emulate F2F interactions, they may see reduced interpersonal conversations (“Chit-Chat”) and jokes amongst the team members. Although currently beneficial to the performance of the short tasks used in this study, the lack of interpersonal interactions in a virtual environment may be an issue. Previous research has interpersonal interactions as crucial to achieving factors related to long-term team effectiveness, such as team cohesion and trust (Demir et al., 2020; Gilson et al., 2013). As such, future research could use longer task durations or study lengths to investigate the effects of virtuality on the relationships between information quality, interpersonal exchanges and team effectiveness.

Using the BiT coding system and iPad in virtual live coding

One of the secondary objectives of the current study was to evaluate the feasibility of using the BiT Coding iPad app to live-code virtual teams. The current study provided evidence of the successful coding of the teams in a virtual setting, even with the cameras off. It is this researcher’s opinion that it is easier to live-code virtual teams due to two factors. The first is the “halo” ring that identifies speakers automatically, making it easier for coders to focus on the content of the interaction being made. The second factor is the clarity of the speaker's voice and the ability to adjust the volume of the conversation, making it easier for coders to listen to the interaction and interpret the contents.

Based on this researcher’s experience, both of these factors unique to virtual coding sessions do help reduce the mental strain needed to accurately live-code team interactions compared to

F2F teams. The current study provides evidence that the BiT coding app is effective in live coding team interactions in a virtual setting with short tasks. However, further studies are needed to evaluate the BiT coding iPad app's ability to code teams in longer task sessions and its effectiveness in providing short-cycle feedback to teams about their dynamics.

Summary

In conclusion, the current study investigated the relationships between team dynamics and idea generation performances and whether virtuality would affect the team's dynamics and creativity performance and affect those relationships. The current findings indicated that a team's dynamics were significantly related to team creativity, and increasing team interaction frequencies would also naturally unbalance the team's participation equity. Hence, a more balanced PER could suggest that the team has a balanced and favourable participation distribution that can promote information exchange or have meagre interaction rates that could result in low information exchange.

This study showed that virtuality could impact the direction and strength of relationships between team dynamics and creativity which could contradict previous research findings or experiences. This highlighted the importance for practitioners and researchers to utilise quantitative (verbal behaviour frequencies) and qualitative (transcripts analysis) metrics to gain a deep understanding of the team's dynamics and how it impacts team effectiveness. The transcripts revealed that virtual teams generally had more task-focused interactions and lesser interpersonal exchanges and "chit chats", which could explain why they outperformed the F2F teams during the GAUT.

The current findings suggested that virtual video conferencing platforms could replicate F2F meetings virtually but might require different team dynamics and processes to facilitate effective team idea generation. The present descriptive data also suggested virtual teams do not communicate as much as their F2F counterparts, which could significantly hinder their

effectiveness. As such, future studies should evaluate the effectiveness of providing virtual teams feedback about their TIF and PER and their effects on subsequent task dynamics and performance.

The current study also showed the feasibility of using the BiT coding app in live coding virtual team interactions. However, further studies are needed to evaluate its ability to live code virtual team interactions in longer task sessions and provide them with short-cycle feedback similar to Study 2 (see Chapter 5).

Table 6-12 Descriptive statistics and correlations of the overall team's frequencies of all 15 individual BiT verbal behaviour categories and number of ideas generated

	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Proposing Procedure	0.16	0.45	--															
2. Proposing Idea	43.09	14.31	-.27	--														
3. Building	11.50	9.16	.46**	-.09	--													
4. Supporting Idea	12.16	11.31	.25	.09	.57**	--												
5. Supporting People	0.69	1.03	.39*	-.05	-.02	-.25	--											
6. Disagreeing	0.16	0.37	.43*	-.03	.24	.24	.22	--										
7. Defending/Attacking	0.09	0.39	.28	-.07	.33	-.03	.08	.34	--									
8. Checking Understanding	2.25	2.60	.33	-.19	.56**	.24	-.15	-.04	.26	--								
9. Seeking Personal Info.	0.31	0.47	-.09	.10	.19	.21	-.26	-.10	.01	.28	--							
10. Seeking Task Info.	2.03	2.09	.03	.23	.11	.22	-.03	-.01	-.24	-.14	.06	--						
11. Giving Personal Info.	7.53	5.72	.27	-.13	.40*	.36*	.06	.02	.30	.26	.40*	.01	--					
12. Giving Task Info.	3.28	2.89	.31	.08	.29	.26	.09	-.01	-	.21	.03	.37*	.13	--				
13. Shutting Out	4.25	5.33	-.15	.47**	-.07	.36*	-.12	-.14	-.07	-.18	.15	.23	.09	.16	--			
14. Bringing in	0.19	0.90	.73**	-.12	.06	-.05	.56**	.40*	-.05	.06	-.07	.15	.01	.04	-.07	--		
15. Lightening The Mood	5.03	6.32	.23	-.01	.42*	.01	.07	.30	.55**	.44*	.24	-.11	.38*	.18	-.01	.20	--	
16. Ideas generated	42.78	14.68	-.21	.95**	-.07	.11	-.02	-.01	-.11	-.27	.02	.23	-.15	.16	.47**	-.07	-.02	--

* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

Table 6-13 Descriptive statistics and correlations of F2F team's frequencies of all 15 individual BiT verbal behaviour categories and number of ideas generated

	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Proposing Procedure	0.50	0.71	--															
2. Proposing Idea	36.90	6.97	-.53	--														
3. Building	21.10	8.01	.21	-.55	--													
4. Supporting Idea	16.40	9.99	.28	-.48	.58	--												
5. Supporting People	0.90	1.37	.52	.28	-.24	-.45	--											
6. Disagreeing	0.30	0.48	.49	-.29	.02	-.14	.39	--										
7. Defending/Attacking	0.20	0.63	.25	-.45	.48	-.08	.03	.51	--									
8. Checking Understanding	4.50	3.06	.03	-.48	.41	.41	-.54	-.26	.17	--								
9. Seeking Personal Info.	0.40	0.52	-.30	.01	-.23	-.01	-.57	-.53	-.27	.28	--							
10. Seeking Task Info.	1.30	1.34	.53	.04	-.09	.15	.38	.19	-.34	-.09	.13	--						
11. Giving Personal Info.	11.30	5.66	.07	-.32	.01	.00	-.25	-.16	.29	-.07	.37	-.45	--					
12. Giving Task Info.	3.30	3.06	.64*	-.77**	.63	.76*	-.15	-.07	.08	.37	.06	.27	.26	--				
13. Shutting Out	0.80	1.03	.91**	-.39	.04	.17	.61	.36	.07	-.28	-.25	.53	.16	.58	--			
14. Bringing in	0.60	1.58	.70*	-.04	-.37	-.30	.75*	.47	-.13	-.21	-.19	.70*	-.27	.07	.70*	--		
15. Lightening The Mood	9.00	8.88	.00	-.48	.15	-.39	-.16	.41	.55	.28	.17	-.16	.16	-.06	-.15	.10	--	
16. Ideas generated	35.70	6.98	-.15	.38	-.28	-.20	.43	-.14	-.59	-.69*	-.33	.08	-.25	-.17	.18	.16	-.43	--

* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

Table 6-14Descriptive statistics and correlations of Virtual (Cameras on) team's frequencies of all 15 individual BiT verbal behaviour categories and number of ideas generated

	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Proposing Procedure	0.00	0.00	--															
2. Proposing Idea	48.73	17.03	--	--														
3. Building	7.09	4.87	--	.41	--													
4. Supporting Idea	6.73	6.20	--	.23	.85**	--												
5. Supporting People	0.64	0.92	--	-.16	.14	-.18	--											
6. Disagreeing	0.00	0.00	--	--	--	--	--	--										
7. Defending/Attacking	0.09	0.30	--	.24	-.01	-.15	.13	--	--									
8. Checking Understanding	2.00	1.84	--	-.04	-.02	.05	-.18	--	.18	--								
9. Seeking Personal Info.	0.27	0.47	--	.35	.38	.48	-.21	--	.52	.35	--							
10. Seeking Task Info.	2.82	2.82	--	.10	.61*	.73*	-.26	--	-.33	-.15	-.03	--						
11. Giving Personal Info.	5.36	3.64	--	.44	.48	.45	-.05	--	.51	-.06	.52	.45	--					
12. Giving Task Info.	4.36	3.53	--	.19	.39	.18	.20	--	-.22	-.11	-.07	.38	.12	--				
13. Shutting Out	5.18	3.79	--	.72*	.21	.03	-.04	--	.07	.44	.25	-.08	.02	.36	--			
14. Bringing in	0.00	0.00	--	--	--	--	--	--	--	--	--	--	--	--	--	--		
15. Lightening The Mood	4.45	4.66	--	.62*	.30	.03	.25	--	.47	-.05	.35	-.12	.18	.41	.66*	--	--	
16. Ideas generated	48.73	17.34	--	.99**	.43	.23	-.13	--	.23	-.13	.31	.09	.42	.18	.66*	--	.62*	-

* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

Table 6-15. Descriptive statistics and correlations of virtual (Cameras off) team's frequencies of all 15 individual BiT verbal behaviour categories and number of ideas generated

	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Proposing Procedure	0.00	0.00	--															
2. Proposing Idea	43.09	15.10	_	--														
3. Building	7.18	6.69	_	.44	--													
4. Supporting Idea	13.73	14.68	_	.49	.59	--												
5. Supporting People	0.55	0.82	_	-.05	-.35	-.27	--											
6. Disagreeing	0.18	0.40	_	.36	.17	.36	-.03	--										
7. Defending/Attacking	0.00	0.00	_	--	--	--	--	--	--									
8. Checking Understanding	0.45	0.69	_	.39	.22	.24	.58	-.33	--	--								
9. Seeking Personal Info.	0.27	0.47	_	.00	.43	.23	.09	.24	--	.20	--							
10. Seeking Task Info.	1.91	1.64	_	.25	.82**	.39	.04	.18	--	.31	.30	--						
11. Giving Personal Info.	6.27	6.20	_	-.14	.10	.38	.36	-.14	--	.46	.35	.32	--					
12. Giving Task Info.	2.18	1.54	_	.29	.28	.45	.47	.42	--	.48	.20	.40	.23	--				
13. Shutting Out	6.45	7.39	_	.36	.66*	.75**	-.26	-.13	--	.43	.37	.42	.56	.25	--			
14. Bringing in	0.00	0.00	--	--	--	--	--	--	--	--	--	--	--	--	--	--		
15. Lightening The Mood	2.00	2.19	_	.06	.26	.54	.39	.00	--	.53	.20	.47	.89**	.53	.63*	--	--	
16. Ideas generated	43.27	15.29	_	1.00**	.45	.49	-.04	.36	--	.41	.00	.26	-.17	.32	.33	--	.04	--

* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

Chapter 7 The effects of feedback on online team dynamics, performance and creativity

Introduction

As mentioned in the previous chapters, organisations view creative and innovative teams as crucial to obtaining an edge over competitors and optimal solutions to organisational challenges (Harvey, 2013; Mumford et al., 2012). The literature review (see Chapter 2) highlighted the importance of team dynamics and its crucial role in facilitating team information exchange. It also showcased other factors related to creative and innovative teams (Apesteguia et al., 2012; Bell et al., 2011; Johnson et al., 2000; Li et al., 2018; Pisani, 2012; Stahl et al., 2010; Thatcher & Patel, 2011; Warner et al., 2012; Zoltan, 2015). However, there were challenges in understanding and obtaining good practice guidelines for team dynamics due to the inconsistent findings of previous literature, lack of accurate measures of team dynamics and effective interventions to improve a team's dynamics (see Chapters 1 & 2 for further details).

In addition to this, the Covid-19 Pandemic and ensuing lockdowns added a new challenge as organisations were forced to adopt full remote working models to maintain organisational productivity during the stay-home lockdowns (Brenan, 2020). These models primarily utilised virtual team collaborations on virtual video conferencing platforms such as Zoom, Microsoft teams, with good practice guidelines developed from previous research to help foster effective virtual team collaborations. However, even with those guidelines, organisations and practitioners still met significant challenges in facilitating effective virtual team collaborations during the Covid-19 Pandemic and lockdowns periods (Belanger et al., 2021; Singh et al., 2021; Waizenegger et al., 2020).

One of the possible explanations for this was that these guidelines were derived from previous research investigating virtuality on team dynamics and effectiveness but primarily on online text-based interaction mediums (e.g., fax, telephone, email, blackboard) (Acai et al., 2018; Alexander et al., 2012; Gilson et al., 2015; Samrose et al., 2018). The limited research on virtual

team collaborations on video conferencing platforms meant that these guidelines were incompatible with the virtual video team collaboration models currently utilised by organisations during the lockdowns (Nadler, 2020; Wiederhold, 2020). An attempt to address the relative lack of research comparing the team dynamics and creative performance of face-to-face (F2F) and virtual teams on virtual video conferencing platforms led to the development of the previous study (see Chapter 6).

The previous study compared the relationships between a team's dynamics and creativity across three levels of virtuality, namely F2F, virtual (Cameras on), and virtual (Cameras off), using the Guilford Alternative Uses Task (GAUT). The results indicated that the relationships between a team's dynamics and creativity could differ based on the virtuality of their meeting environment. The results also suggested that camera usage significantly impacted a team's PER but did not significantly impact a team's creativity and TIF. However, this significant difference in PER was attributed to the low interaction rates in virtual teams without active cameras.

The findings of the previous study also suggested that increasing the interaction frequencies (TIF) of virtual teams would significantly improve their creativity. However, the data also revealed that virtual teams had lower TIF than F2F teams, suggesting that virtuality could hinder information exchange and communication between team members. It was recommended for future studies to evaluate the effectiveness of feedback as an intervention to increase the TIF, balance the PER of virtual teams and improve performance for subsequent tasks.

Previous research suggested that providing teams with feedback would improve their team dynamics and performance for subsequent sessions, but little to no research used the team's dynamics data to provide said feedback (Gabelica et al., 2012, 2014a, 2014b; Konradt et al.,

2015; O'Neil et al., 2018, 2020; Tausczik & Pennebaker, 2013). The findings from Study 2 (see Chapter 5) indicated that providing teams feedback about their TIF and PER improved their team's dynamics and performance for subsequent sessions of a creative problem-solving (innovation) task. It also recommended measuring a team's dynamics for an entire task iteration and providing feedback before commencing the next iteration.

The current study built upon the findings of Studies 2 & 3 and replicated the methodology and tasks used in Study 2 (see Chapter 5) virtually with virtual teams recruited as participants. This replication also saw team dynamics feedback only given after an iteration of the GAUT and the creative problem-solving task. This provided the data required to assess the effectiveness of team dynamics feedback in improving the team's dynamics and performance for subsequent creativity and innovation tasks. It would also provide further insights into the following research questions and associated hypotheses derived from previous research and findings obtained from this PhD.

1) Is a virtual team's dynamics significantly related to the team's creativity?
    a. TIF has a positive relationship with a virtual team's creativity.
    b. PER has a positive relationship with a virtual team's creativity.
2) Is a virtual team's dynamics significantly related to the team's innovation?
    a. TIF has a positive relationship with a virtual team's innovation
    b. PER has an inverse relationship with a virtual team's innovation.
3) Would giving virtual teams feedback about their team dynamics as an intervention improve their subsequent task dynamics and performance?
    a. Teams receiving feedback would have increased TIF
    b. Teams receiving feedback would have a more balanced PER
    c. Teams receiving feedback would have better task performance

4) What verbal behaviours and interaction trends affect effective virtual creative and innovative teams?

The current study aimed to provide more evidence and insights about the feasibility of using the BiT Coding iPad to live code the interactions of virtual teams. More importantly, it examined the BiT coding iPad app's ability to provide effective short-cycle feedback to virtual teams about their dynamics across various tasks in a similar manner in a F2F context.

Methods

Participants

A total of 136 students (113 females and 23 males) aged 18-39 years old (M =19.75, SD = 1.73) from Cardiff University were recruited to participate in the study through the University's Research Participation System (SONA). This provided a total of 34 participant teams consisting of 4 members each. The recruitment criteria required participant teams to email the researcher about any previous experiences working with all the other team members. The participant teams recruited for this study all had at least eight continuous weeks of experience working together on academic projects.

Participants were compensated with either course credits or cash payment as determined by the rate set by Cardiff University's Psychology Department. The study received ethical approval from Edge Hill University's School Research Ethics Committee (Ref: BT/03-2019/064) and Cardiff University's Psychology Department's Research Ethics Committee. All protocols for obtaining informed consent, GDPR and Debriefing were adhered to (See Appendix F for the ethics approval letters).

Materials

Guilford's Alternative Uses Task (GAUT)

The Guilford Alternative Uses Tests (GAUT) developed from Guilford's (1967) Structure of Intellect were used to measure the team's idea generation performance. The most common

example of this test was "*Please list all the uses you can think of for a brick/pen.*" (de Bloom et al., 2014; Runco & Acar, 2012).

For the current study, teams were given two five-minute sessions to develop as many possible uses for a mug and a paperclip. The team used a screen-shared Microsoft Office Word document viewable by all team participants to record the ideas generated. This reduced the need for researcher interaction with the participating teams during the task and helped prevent the introduction of a confounding variables such as an experimenter effect or bias.

The GAUT was scored by reviewing all the named uses for the item given and combining duplicate/similar uses (e.g., using a pen for writing and drawing are similar). After reviewing both objects, the total number of accepted ideas would reflect the team's overall idea generation performance.

Bridgebuilding task (Polybridge)

Findings and transcripts analyses from Study 2 resulted in recommendations for the time allocated to teams during the creative problem-solving task to focus on ideating solutions for the task. Incorporating this recommendation in the current task design would potentially reduce the time teams dedicate to building prototypes and result in more interactions amongst each other.

The video game, Polybridge by Cactus Studios was chosen as the virtualised version of the bridge-building task, which served as the creative problem-solving task for this study. The game was picked as it contained standardised performance measures and did not require participant teams to complete a physical prototype. This thus provided more time for teams to ideate and communicate how to complete the task.

The current task (level 1-1 of the game) saw participant teams given three 10-minute sessions to ideate and design the cheapest and strongest bridge to successfully allow a vehicle to cross a river (See Figure 7-1). The team would have to relay and direct a neutral confederate to build

their bridge design at the end of each session. This ensured participant teams had 10 minutes dedicated to communicating with each other and designing a successful bridge. Having a confederate build their design will help account for the participant's unfamiliarity with the game-building mechanics and reduce time wastage.

Figure 7-1: Screenshot of the design and building interface of the video game Polybridge

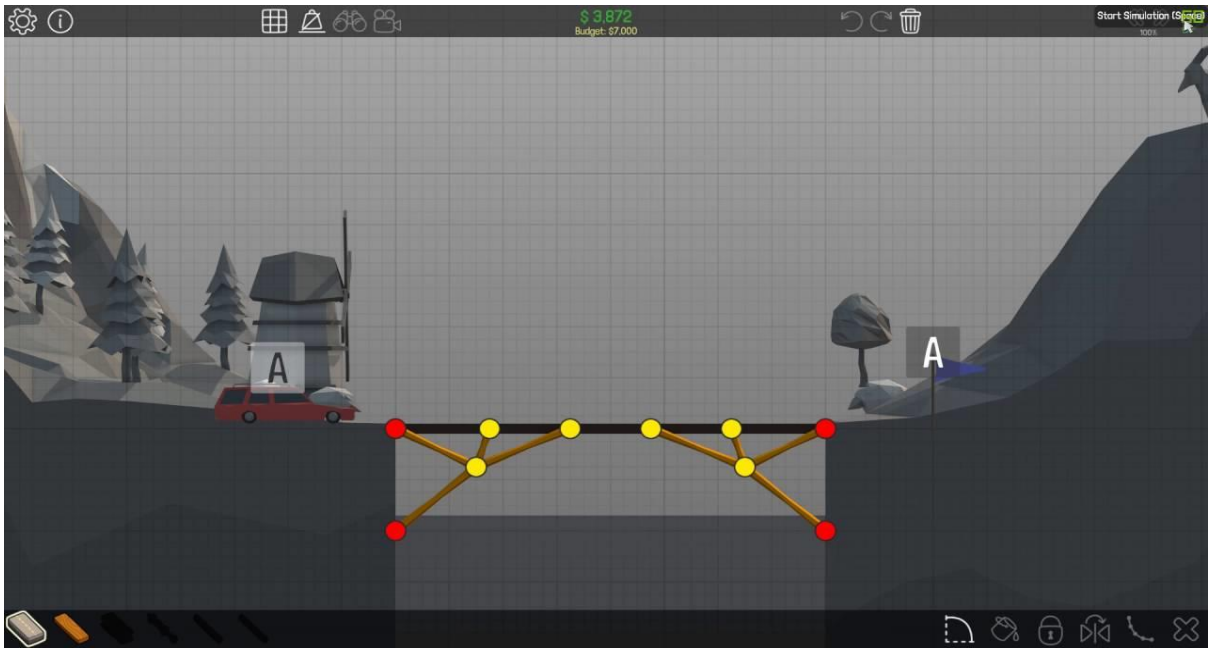
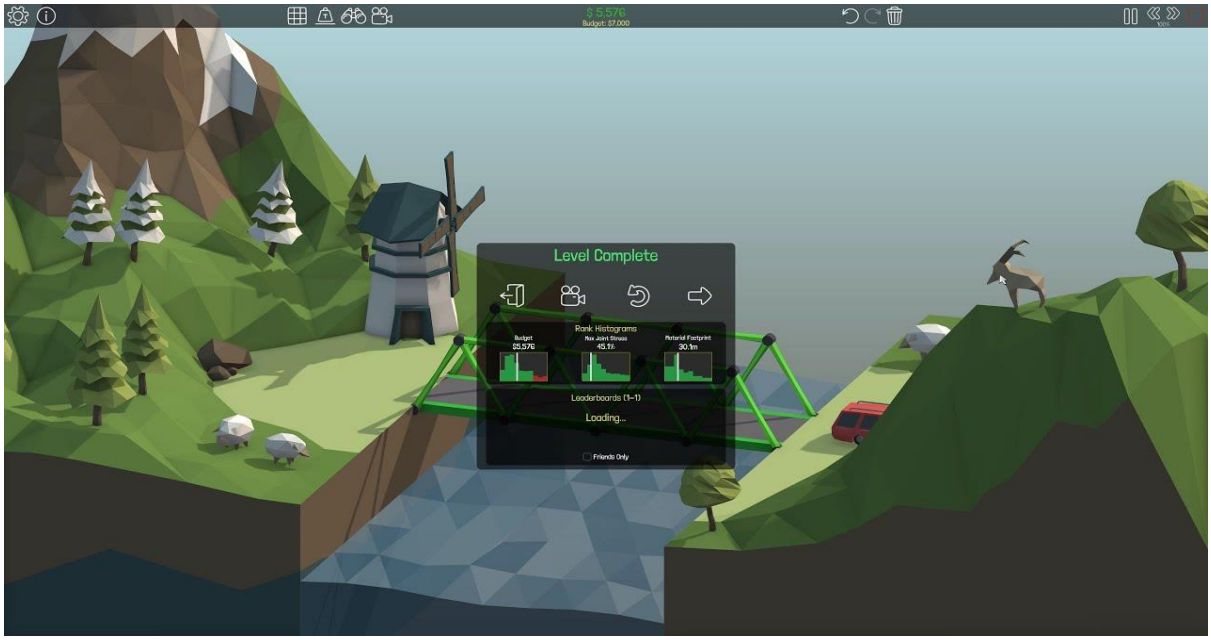


Figure 7-2: Screenshot of the performance summary upon successful completion of the level.



The team's creative problem-solving performance was measured by the number of points scored by the team across three components: 1) Bridge Crossing Outcome, 2) Bridge Design Cost, and 3) Maximum Bridge Joint Stress Endured (See Figure 7-2). Teams with successful bridge crossings were awarded 30 points, while failed bridge crossing attempts were awarded 15 points. If the current attempted bridge failed to support the combined weight of itself or the car crossing on it, resulting in its collapse, the current attempt was deemed to have a failed bridge crossing.

Points were awarded to the team's bridge design cost and maximum joint stress endured, with a maximum of 10 points for each category. The associated value ranges for the point allocation of both categories were taken from the histograms showcasing the value ranges of successful designs for level 1-1 of the game (Figure 7-2 above). The breakdown of the point allocation system for bridge design cost and maximum joint stress endured are listed in Table 7-1.

Table 7-1. Points allocation for bridge crossing outcome, bridge design cost and maximum stress endured

Bridge Design Cost ($)	Points awarded	Maximum joint stress endured (%)	Points awarded
$4143 and below	+10	42.4% and below	+10
$4144 - $4564	+9	42.5% - 48.3%	+9
$4565 – $4984	+8**	48.4% - 54.2%	+8
$4985 - $5404	+7	54.3% - 60.1%	+7
$5405 - $5824	+6	60.2% - 66.1%	+6
$5825 -$6244	+5	66.2% - 72.0%	+5
$6255 - $6664	+4	72.1% - 77.9%	+4
$6665 - $7084	+3	78.0% - 83.8%	+3
$7085 - $7504	+2	83.9% - 89.7%	+2
$7505 - $7924	+1	89.8% - 95.6%	+1
$7925 and above	+0	95.6% – 100.00%*	+0

* If the bridge crossing attempt fails, maximum points awarded for bridge design cost capped at 8
** Failed bridge designs have a 100% joint stress endured

The following are examples of scores awarded for a team's three bridge crossing attempts using the points allocation system. The first attempt had a successful bridge crossing (+30 points), design cost of $5950 (+5 points) and maximum joint stress endured percentage of 65% (+6 points) would be awarded 41 points. The second attempt had a failed bridge crossing (+15 points), design cost of $4465 (+8 points, capped due to bridge failure) and a maximum stress endured percentage of 100% (+0 points) would be awarded 23 points. The third attempt had a failed bridge crossing (+15 points), design cost of $6850 (+3 points) and a maximum stress endured percentage of 100% would be awarded 18 points. As such the team in this example would have a grand total of 82 points (41 + 23 + 18 points) being awarded for their three attempts on the bridgebuilding task.

BiT coding system

The verbal behaviours exhibited by the teams during the study were coded by trained observers using the 15-category Behaviour in Teams (BiT) coding system iPad app (Farley et al., 2018; Rackham & Morgan, 1977). The 15 categories of the BiT coding system (Farley et al., 2018) are listed below in its four meta-categories (see Table 7-2), with descriptions for each category found in Appendix A.

Table 7-2. The 15 BiT coding verbal behaviours divided into four meta categories

Initiating	Reacting	Clarifying	Balancing/Process
1. Proposing Procedures	4. Supporting Ideas	8. Checking Understanding	13. Shutting Out
2. Proposing Ideas	5. Supporting People	9. Seeking Task Information	14. Bringing in
3. Building	6. Disagreeing	10. Seeking Personal Information	15. Lightening the Mood

7. Defending/ Attacking	11. Giving Task Information 12. Giving Personal Information

Obtaining a team's TIF and PER

The verbal behaviours exhibited by the team during the GAUT and the bridgebuilding task were coded into their respective 15 BiT categories and tallied. Each team would have a total tally of individual behaviours exhibited and a breakdown of the behavioural frequencies of every team member, which provides a team total (TIF) and standard deviation of interaction rates (PER). Higher TIF would suggest teams had more interactions, while low TIF indicated little interaction or communication.

The standard deviation or spread of verbal behavioural frequencies against the team's average indicated the team's PER. A standard deviation closer to 0 indicated that the team had very balanced PERs, whilst higher standard deviations would suggest unequal participation equity rates amongst the team members. This replicated the approach Samrose et al. (2018) applied in their study on feedback and PER.

BiT Observer Training

Observers (coders) wanting to utilise the BiT coding system required specialist training to ensure objective and accurate coding of verbal behaviours with high inter-rater reliability (Farley et al., 2018). The training for the observers consisted of two parts, the first being a video-based learning course found on the iPad app version of the BiT coding system, followed by a facilitator-led training session. The video-based training required observers to watch pre-recorded videos introducing the 15 categories in sequence and practice coding the various categories using pre-recorded audio tapes provided in the BiT iPad app. Observers needed to pass the video-based training session before attending the facilitator-led training session to live-code simulated live team meetings.

The observers' coding accuracy was monitored throughout the training via a Cohen's kappa value at the end of each simulated audio tape or mock coding session. The Cohen's Kappa value was derived by comparing the observers' codes against the answer key in the BiT iPad app or provided by the facilitator during their training session. Observers passed the training course when their Cohen Kappa score on the final test given by the facilitator was equal to or higher than k =.85.

Providing teams feedback

As part of BiT coding training, observers were taught how to utilise the data analyses generated at the end of a session to provide teams with immediate feedback about their team dynamics. Observers provided feedback to the teams using the steps listed below:

1. Observers showed and described the summary of the team's coded verbal behaviours and patterns.
2. The team was given opportunities to ask questions about each behavioural category and its meaning.
3. Observers asked the team what they felt about their interaction patterns and what they thought about the feedback given.
4. Observers concluded the feedback session by asking the team to note if changes were to be made to their interaction patterns before commencing the session.

The main aim of the feedback was to explicitly show both individuals and the team their interaction patterns and provide time for reflecting on the information provided. The feedback session concluded by letting teams decide if modifications to behaviours were needed to improve their team's interaction patterns and performance. It is noted that the observer's role during the feedback session was to guide the team through a reflection process and avoid making the feedback process elicit biases towards the observer's ideal of how a team should

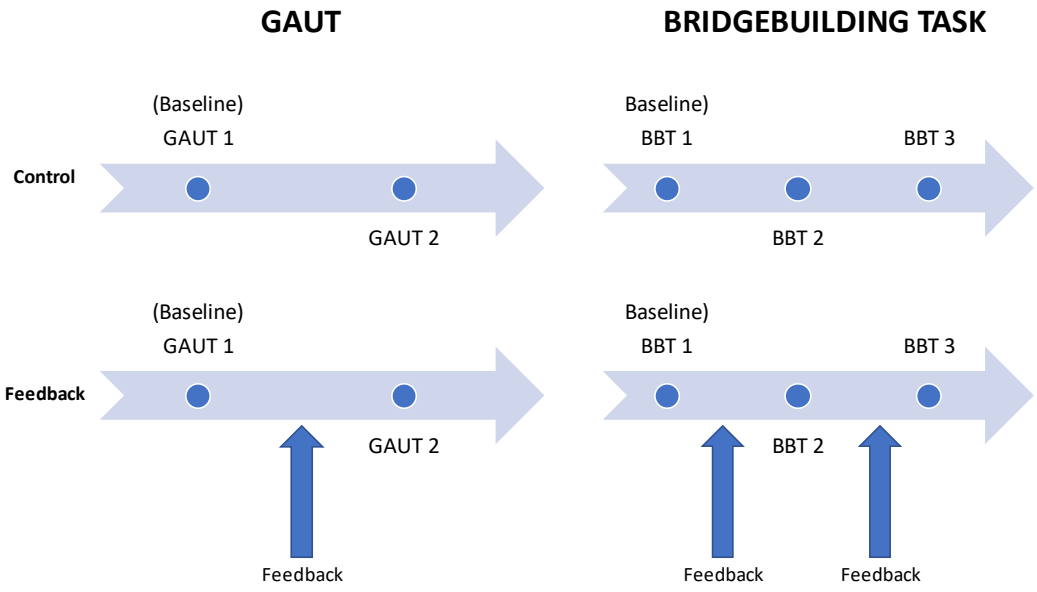
communicate. The feedback session was done virtually by sharing the data summaries page to all participants using the video conferencing platform's share screen function. After the initial feedback session concluded, the participants could then request the different information types to be shown on screen to aid their reflection on their dynamics.

Design

The current study utilised a two-condition between-subjects design: 1) the Control condition, where teams performed both experimental tasks without receiving feedback, and 2) the Feedback condition, where teams received feedback about their team's interaction patterns at specific intervals. Figure 7-3 is a flowchart of the entire experimental flow and intervals where feedback is provided to the participant teams.

Each participant team completed all the tasks with their Cameras on. A trained observer live coded teams' verbal interactions and used the data summaries to give feedback to teams in the feedback condition. The study audio and video recorded all participant teams while completing both experimental tasks, with recordings stopped while feedback was given. Counterbalancing for the GAUT was done by alternating the item presented first to the participant teams.

Figure 7-3: Flowchart of the study for both experimental conditions



Procedures

The study was conducted virtually on Zoom, with recruited participant teams given a Zoom link to join on the day of the study. Participants were briefed by the researcher and gave informed consent given to participate in the study and be audio and video recorded throughout the tasks. Participant teams were then briefed on the GAUT instructions and given opportunities to ask questions before the task started. Each team was then given 5 minutes to list as many possible, creative and alternative uses for a mug and a paperclip. Alternation of the item presented first to participant teams was done for counterbalancing. At the end of the first session, teams in the feedback condition were given feedback about their team's dynamics before starting the second session.

After completing the second GAUT session, the teams were briefed about the bridgebuilding task and completed the standardised tutorials found in the game used for the task. The teams were taught how to relay their bridge designs to the neutral confederate controlling the in-game building system and given opportunities to ask questions before the task started. For each task iteration, teams were given 10 minutes to develop the cheapest and strongest bridge design that could support its weight and allow safe passage of the target vehicle across the other side. After each iteration, teams in the feedback condition were given feedback their team dynamics before starting the next iteration. After completing the bridgebuilding task, participants were asked to complete a basic demographic questionnaire. The entire study took no more than an hour to complete, and participants were debriefed verbally at the end of the study and provided with a debriefing sheet.

Data Analysis

The collated data for each experimental task was divided into their baseline, and subsequent sessions with the following analyses conducted to answer the formulated research questions. Correlational analyses were conducted on the collected data of the team's TIF, PER and task performance scores for the baseline sessions of both experimental tasks. The data from the

analyses would help provide insights into the team dynamics and processes related to effective virtual team creativity and innovation.

Paired-samples t-tests (GAUT), One-way repeated measures ANOVA (Bridgebuilding) and two-way mixed design ANOVA would be conducted to investigate the effects of providing teams feedback on their team dynamics on subsequent task performance and team dynamics. The TIF, PERs and task performance scores for all experimental task sessions would be collated and used in the analyses. The analyses will help reflect any significant effects of feedback on subsequent team performance and dynamics while accounting for practice effects across time.

The teams' frequencies of the 4 meta and 15 individual BiT verbal behaviours exhibited during the baseline sessions of both experimental tasks would be tallied. Correlational analyses would then be conducted between the team's performance for each task baseline performance on their associated tallied 4 meta and 15 BiT verbal behaviour frequencies.

Results

GAUT data analyses

This section contains the data analyses for the GAUT, which is divided into two subsections. The first section analyses the collated data of the first GAUT session; the second section analyses the collated data of both GAUT sessions to investigate the effects of feedback on the team's dynamics and performance.

GAUT 1 (Baseline) session data analysis

Pearson correlations were conducted between the team's GAUT score (M = 20.06, SD = 6.31) with their TIF (M = 37.62, SD =21.10) and PER (M = 5.04, SD = 2.97) for the first GAUT session. The results indicated that increased TIF significantly increased the number of ideas teams generated, r = .84, p <.001. The results also indicated an unequal PER significantly increased the number of ideas teams generated, r = .56, p <.001. Increasing the TIF also significantly increase PER inequality, r = .66, p <.001 (See Table 7-3).

Table 7-3.Descriptive statistics and correlations of the team's recorded frequencies for TIF, PER and ideas generated

	Mean	SD	1	2	3
1. TIF	37.62	21.10	-		
2. PER	5.04	2.97	.66*	-	
3. Ideas generated	20.06	6.31	.84*	.56*	-

*. Correlation is significant at the < .01 level (2-tailed)

Pearson correlations were conducted to investigate if frequencies of the 4 meta-BiT verbal behaviour categories of 'Initiating', 'Reacting', 'Clarifying' and 'Balancing' were correlated to the number of ideas participant teams. The results indicated that increasing a team's frequencies of 'Initiating' (r = .93, p <.001), 'Reacting' (r = .67, p <.001), 'Clarifying' (r = .51, p <.001), 'Balancing' (r = .66, p <.001) verbal behaviours significantly increased the number of ideas generated. The descriptive data and correlation matrix are shown in Table 7-4 below. Further Pearson correlations were conducted to investigate whether any of the 15 individual BiT verbal behaviours significantly impacted the teams' idea generation performances (See Table 7-3 above for descriptive statistics and correlation matrix). The results indicated significant correlations found between the team's GAUT score with their 'Proposing ideas' (r = .99, p < .01), 'Building' (r = .64, p < .01), 'Supporting ideas' (r =.65, p <.01), 'Defending/Attacking' (r = .40, p = .019), 'Giving personal information' (r = .56, p <.01), 'Shutting out' (r = .59, p <.01) and 'Lightening the mood' (r = .60, p <.01) verbal behaviours.

Table 7-4. Descriptive statistics and correlations of the team's recorded frequencies for the four meta-BiT verbal behaviour categories and the number of ideas generated

	Mean	SD	1	2	3	4	5
1. Initiating	24.53	9.20	-				
2. Reacting	5.21	5.78	.70*	-			
3. Clarifying	5.68	5.72	.59*	.73*	-		
4. Balancing	2.21	3.47	.62*	.76*	.71*	-	

5. Ideas generated	20.06	6.31	.93*	.67*	.51*	.66*	-

*. Correlation is significant at the < .01 level (2-tailed)

GAUT 2 (post-feedback) session data analysis

The collated data of participant teams' TIF, PER and number of ideas generated, for both iterations of the GAUT were used to examine the effects of feedback on subsequent task performance and communication patterns (see Tables 7-3 – 7-5). This was examined using a two-way repeated measures ANOVA with Feedback (Control vs Feedback) as the between-subject factor and Time (Baseline vs Post Feedback) as the within-subject factor. Paired sample t-tests were also conducted to test for significant differences between the data of the first session and second session for the 16 participant teams in the feedback and control condition.

Feedback and Time on TIF

The analysis showed no significant differences between the teams' TIF between both experimental conditions, $F(1, 32) = .17$, $p = .684$, $\eta_p^2 = .005$. There was a significant difference between the first and second sessions of the GAUT, $F(1, 32) = 7.202$, $p = .011$, $\eta_p^2 = .184$. There were no significant interactions between the two factors on the teams' TIF, $F(1, 32) = .96$, $p = .334$, $\eta_p^2 = .009$ (See Figure 7-4). The paired sample t-test analysis on the 16 teams receiving feedback found significant differences between the teams' TIF for pre- and post-feedback GAUT sessions, $t(1, 16) = -2.72$ $p = .015$. The paired sample t-test for teams in the control condition indicated no significant differences between the teams' TIF for pre- and post-feedback GAUT sessions, $t(1, 16) = -1.15$ $p = .267$

Table 7-5. Means and Standard deviations of the teams' total interaction frequency (TIF) for both GAUT sessions

	Total Interaction Frequency (TIF)			
	1st session		2nd session	
	Mean	SD	Mean	SD

Control	40.41	17.55	45.00	24.10
Feedback	34.82	24.36	44.71	22.58

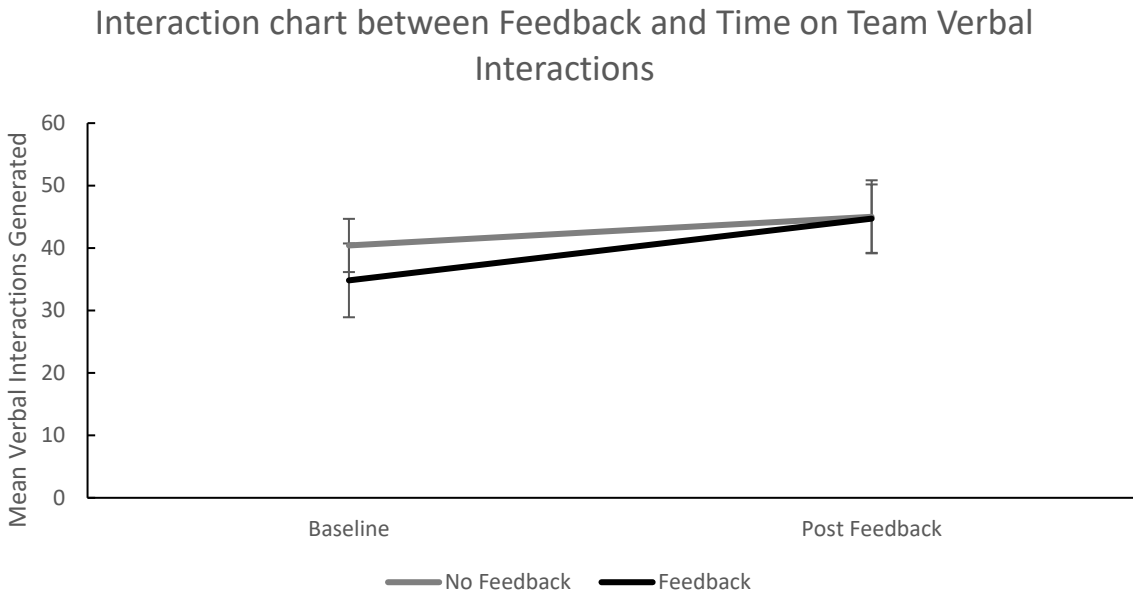


Figure 7-4 Mean number of verbal interactions generated for both control and intervention teams during both halves of the GAUT. Error bars represent the standard errors of the mean.

Feedback and Time on PER

The analysis showed no significant differences in the teams' PER between both experimental conditions ($F(1, 32) = .002$, $p = .962$, $\eta_p^2 = .000$) and no significant differences between both iterations of the GAUT ($F(1, 32) = .02$, $p = .882$, $\eta_p^2 = .001$). No significant interactions were found between both factors on the teams' PER, $F(1, 32) = 1.75$, $p = .195$, $\eta_p^2 = .052$ (See Figure 7-5). The paired sample t-test analysis on the feedback condition found no significant differences between the team's PER for pre- and post-feedback GAUT sessions, $t(1, 16) = -.93$, $p = .366$. The paired sample t-test analysis on the control condition found no significant differences between the team's PER for pre- and post-feedback GAUT sessions, $t(1, 16) = .96$, $p = .350$.

Table 7-6.Means and Standard deviations of the teams' PER for both GAUT sessions

	Participation Equity Rate (PER)			
	1st session		2nd session	
	Mean	SD	Mean	SD
Control	5.41	2.59	4.79	2.37
Feedback	4.67	3.34	5.44	3.78

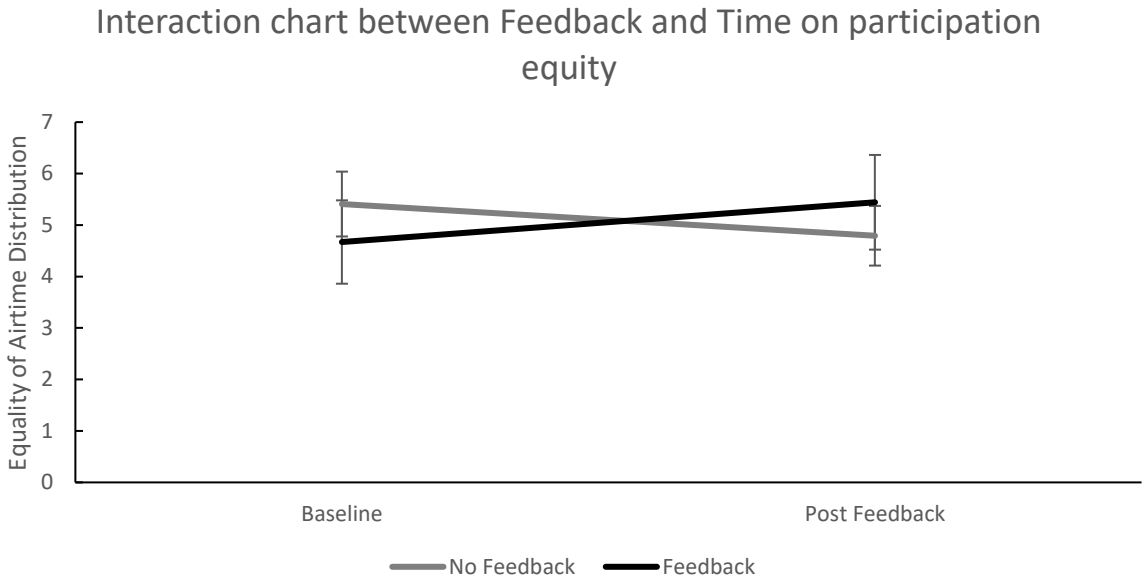


Figure 7-5 Mean PERs for control and intervention teams during both halves of the GAUT. Error bars represent the standard errors of the mean.

Feedback and Time on Idea generation

The analysis showed no significant differences in the numbers of ideas generated by participant teams between both experimental conditions, $F(1, 32) = .86$, $p = .360$, $\eta_p^2 = .026$ and no significant differences between both iterations of the GAUT, $F(1, 32) = 3.13$, $p = .087$, $\eta_p^2 = .089$. There were no significant interactions between feedback and time on the number of ideas generated by teams, $F(1, 32) = 1.50$, $p = .230$, $\eta_p^2 = .045$ (See Figure 7-6). The paired sample t-test analysis on the feedback condition found significant differences between the team's number of ideas generated for pre- and post-feedback GAUT sessions, $t(1, 16) = -2.33$, $p =$

.033. The paired sample t-test analysis on the control condition found no significant differences between the team's number of ideas generated for pre- and post-feedback GAUT sessions, $t(1, 16) = -.36$, $p = .727$.

Table 7-7. Means and Standard deviations for the total number of ideas teams generated for both GAUT sessions

	Number of Ideas			
	1st session		2nd session	
	Mean	SD	Mean	SD
Control	21.47	4.90	21.94	5.96
Feedback	18.65	7.35	21.24	5.88

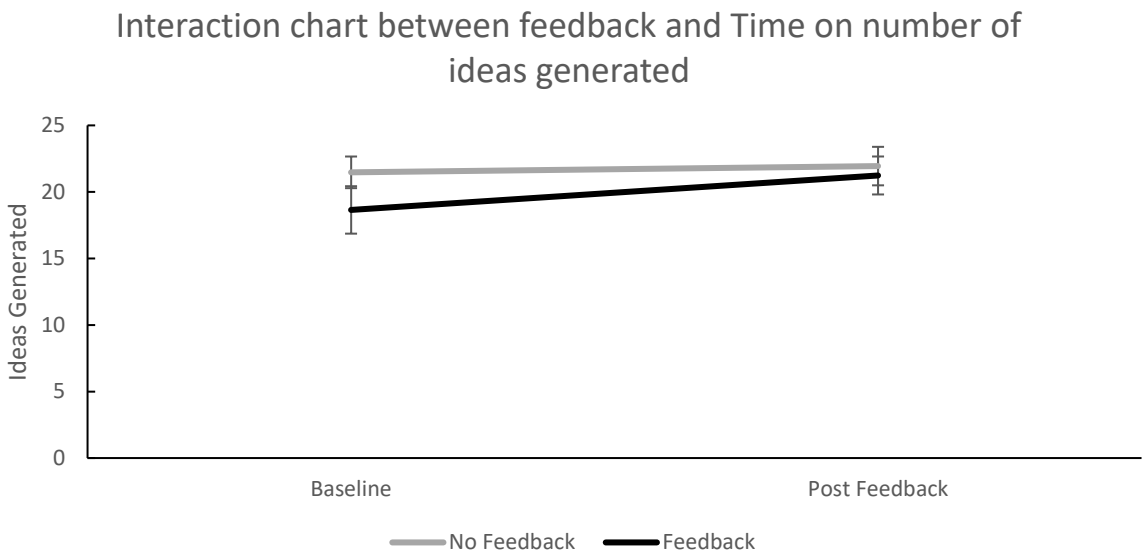


Figure 7-6 Mean number of ideas generated for both control and intervention teams during both halves of the GAUT. Error bars represent the standard errors of the mean.

Bridgebuilding (Innovation) data analysis

This section contains the data analyses for the bridgebuilding task, divided into two subsections. The first section analyses the collated data of the first bridgebuilding session; the second section analyses the collated data of all three bridgebuilding sessions to investigate the effects of feedback on the team's dynamics and performance.

Baseline Analysis

Pearson correlations were conducted to check for significant correlations between teams' bridgebuilding task performance (M = 63.53, *SD* = 21.86) on their TIF (*M* = 83.76, *SD* = 36.82) and PER (*M* = 9.48, *SD* = 5.57). The results indicated a non-significant positive correlation between a team's TIF on their bridgebuilding task performance, $r = .04$, $p = .823$. The results also indicated a non-significant inverse correlation between a team's PER on their bridgebuilding task performance, $r = -.07$, $p = .690$. The descriptive statistics for the TIF, PER and task scores for the first bridgebuilding session are recorded in Table 7-8.

Table 7-8. Descriptive statistics and correlations for TIF, PER, and bridgebuilding task performance for the baseline session.

	Mean	SD	1	2	3
1.TIF	83.76	36.82	--		
2. PER	9.48	5.57	.44**	--	
3. Task performance	31.76	10.93	.04	-.07	--

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Pearson correlations were conducted to investigate whether frequencies of the 4 meta-BiT verbal behaviour categories correlated to teams' bridgebuilding performance. The results indicated 'Initiating' ($r = -.10$, $p = .573$) and 'Balancing' ($r = -.08$, $p = .673$) verbal behaviours had a non-significant negative correlation on bridgebuilding scores. 'Reacting' ($r = .04$, $p = .844$) and 'Clarifying' ($r = .15$, $p = .413$) verbal behaviours had a non-significant correlation with a team's bridgebuilding scores. The descriptive data and correlations matrix for each category with the team's bridgebuilding scores are shown in Table 7-9.

Table 7-9. Descriptive statistics and correlations of the team's recorded frequencies for the four meta-BiT verbal behaviour categories and Bridge building task performance

	Mean	SD	1	2	3	4	5

1. Initiating	26.83	14.24	-				
2. Reacting	15.56	8.03	.13	-			
3. Clarifying	36.35	20.67	.49**	.24	-		
4. Balancing	5.56	5.19	.63*	.39*	.53**	-	
5. Task Performance	31.76	10.93	-.10	.04	.15	-.08	-

*. Correlation is significant at the .05 level (2-tailed)

**. Correlation is significant at the .01 level (2-tailed)

Further Pearson correlations investigated whether the 15 individual BiT verbal behaviours significantly correlated with the teams' bridge-building task performance (See Table 7-9 for the descriptive statistics and correlation matrix). The results indicated no significant correlations between a team's recorded frequencies on all 15 BiT verbal behaviour categories on their bridgebuilding performance. The correlation matrix also showed that increased frequencies of 'Proposing ideas' (r = -.17), 'Building' (r = -.18), 'Supporting people' (r = -.03), 'Disagreeing' (r = -.18), 'Seeking task information' (r = -.06), 'Shutting out' (r = -.13) and 'Bringing in' (r = -.12) verbal behaviour categories had adverse effects on team bridgebuilding performance.

Post-feedback analysis

The collated data of the participant team's TIF (Table 7-8), PERs (Table 7-9) and bridge-building task performance (Table 7-10) from all three iterations of the bridgebuilding (BBT) task were used to explore the effects of providing teams feedback about their communication patterns on future iterations of the same task.

Each outcome measure was examined by using a mixed two-way ANOVA with Feedback (Control vs Feedback Given) serving as the between-subject factor and Time [BBT1 (Baseline) vs BBT2 (Feedback 1) and BBT3 (Feedback 2)] serving as the within-subject factor. The analyses for each outcome measure are listed in the sections below.

Feedback and Time on TIF

Table 7-10. Means and Standard deviations of the teams' TIF across all three iterations of the bridgebuilding task across both experimental conditions

	BBT 1		BBT 2		BBT 3	
	Mean	SD	Mean	SD	Mean	SD
Control	83.18	40.31	81.59	30.53	89.18	39.39
Feedback	84.35	34.22	74.71	27.01	85.06	32.22

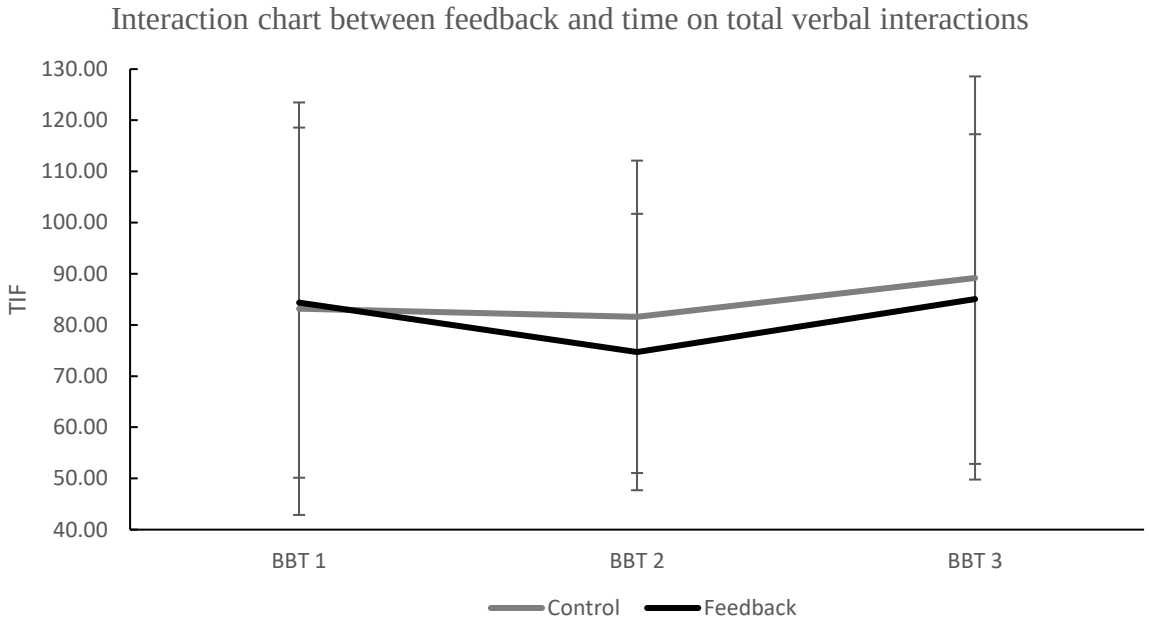


Figure 7-7 Mean number of TIF generated for both control and intervention teams during all three interactions of the bridgebuilding task. Error bars represent the standard errors of the mean.

The analysis showed no significant differences in the total number of verbal interactions between participant teams in both experimental conditions [$F(1, 32) = .18$, $p = .678$, $\eta_p^2 = .005$] and no significant differences across all three iterations of the bridgebuilding task [$F(1, 32) = .17$, $p = .695$, $\eta_p^2 = .005$]. There were no significant interactions between feedback and time on the total verbal interactions exhibited by the participant teams, $F(1, 32) = .10$ $p = .757$, $\eta_p^2 = .003$ (See Figure 7-7).

Feedback and Time on PER

Table 7-11. Means and Standard deviations of the teams' PERs for all three iterations of the bridgebuilding task across both experimental conditions

	BBT 1		BBT 2		BBT 3	
	Mean	SD	Mean	SD	Mean	SD
Control	9.99	7.01	8.37	4.62	9.64	5.14
Feedback	8.97	3.80	8.36	2.96	9.58	6.38

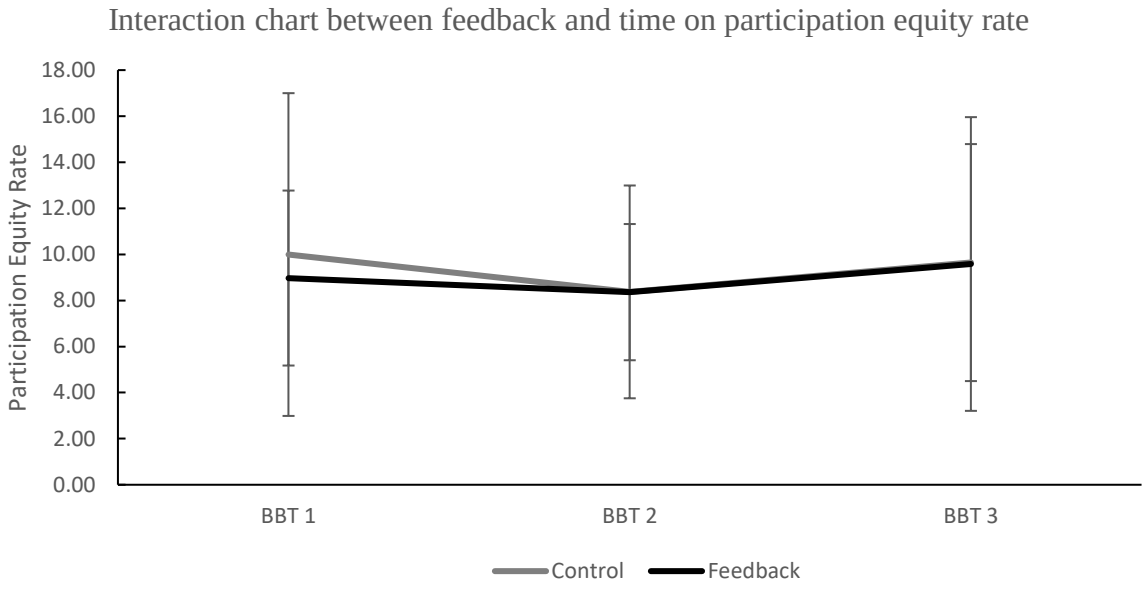


Figure 7-8 Mean PER generated for both control and intervention teams during all three interactions of the bridgebuilding task. Error bars represent the standard errors of the mean.

The analysis showed significant differences in the PER by participant teams in both experimental conditions [$F(1, 32) = .18$, $p = .678$, $\eta_p^2 = .005$] and no significant differences across all three iterations of the bridgebuilding task [$F(1, 32) = .16$, $p = .695$, $\eta_p^2 = .005$]. There were no meaningful interactions between feedback and time on the PER exhibited by the participant teams, $F(1, 32) = .10$, $p = .757$, $\eta_p^2 = .003$ (See Figure 7-9).

Feedback and Time on Bridgebuilding task performance

Table 7-12. Means and Standard deviations of the teams' bridgebuilding task performance across all three iterations of the bridgebuilding task across both experimental conditions

	BBT 1		BBT 2		BBT 3	
	Mean	SD	Mean	SD	Mean	SD
Control	32.76	11.24	32.35	12.38	36.06	10.80
Feedback	30.76	10.86	33.06	10.83	35.24	11.60

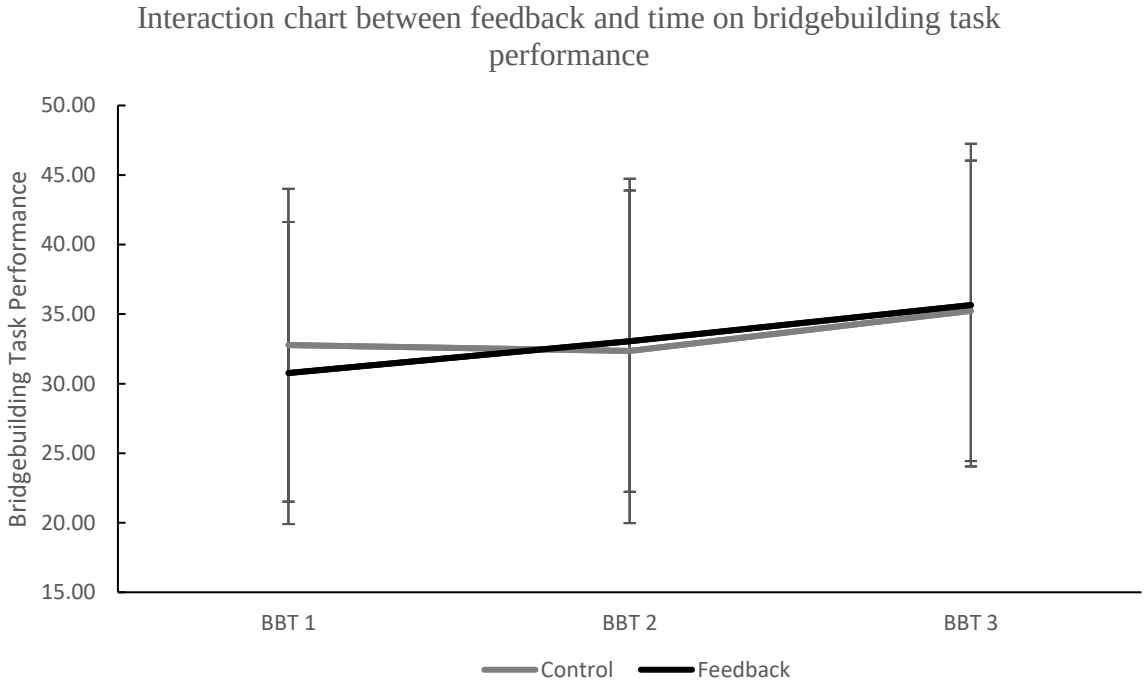


Figure 7-9: Mean number of TIF generated for both control and intervention teams during all three interactions of the bridgebuilding task. Error bars represent the standard errors of the mean.

The analysis showed no significant differences in bridgebuilding task performance scores between participant teams in both experimental conditions [$F(1, 32) = .06$, $p = .802$, $\eta_p^2 = .002$] and no significant differences across all three iterations of the bridgebuilding task [$F(1, 32) = 2.55$, $p = .120$, $\eta_p^2 = .074$]. There were no significant interactions between feedback and time on the teams' bridge-building task score, $F(1, 32) = .06$, $p = .811$, $\eta_p^2 = .002$ (See Figure 7-7)

Discussion

The current study had three aims. The first was to obtain further insights into the relationships between team dynamics, creativity and innovation for virtual teams. The second aim was to evaluate the effectiveness of feedback in improving a team's dynamics and performance in subsequent task iterations. The third aim was to evaluate the feasibility of using the BiT coding iPad app to live code virtual teams and also use its data summaries to provide teams with short-cycle feedback. Thirty-four virtual participant teams with their Cameras on were randomly allocated to two experimental conditions (control and feedback). They completed two iterations of the GAUT and three iterations of the bridgebuilding task. The participant teams were audio and video recorded throughout the experimental tasks and obtained transcripts that can give more context regarding the verbal exchanges exhibited by the participant teams.

The discussion section will be divided into three sections. The first section will discuss the findings regarding the team's dynamics of effective virtual team idea generation (GAUT) performance; the second section will discuss the results regarding the team's dynamics of effective virtual team innovation (Bridgebuilding) performance. The third section will discuss the effectiveness of providing virtual team dynamics feedback on subsequent task performance and communication profiles. Further insights of using the BiT Coding iPad app in a virtual setting and future research directions will also be discussed.

Team dynamics of effective virtual team idea generation (GAUT baseline)

The analyses of the overall relationships between the team's dynamics on their creativity suggested a team's TIF had a significant positive correlation with their idea generation performance and accepted hypothesis 1a, which predicted a virtual team's TIF had positive relationships with their creativity. This was consistent with the results of Study 3 (see Chapter 6) and previous research findings showing that increased team interactions resulted in better

idea-generation performance (Johnson et al., 2000; Li et al., 2018; Pisani, 2012; Warner et al., 2012; Zoltan, 2015).

The analyses also showed significant positive correlations between a team's PER and creativity, supporting hypothesis 1b and the results of Study 3, which predicted that a more imbalanced team PER would improve the team's creativity. The analyses also showed a significant positive correlation between the team's TIF and PER, suggesting that increased team interactions naturally increased the imbalance of team member participation equity. This means that a more balanced team PER could signal equal participation amongst team members or a lack of verbal interaction in general for virtual teams.

The transcripts and task recordings indicated that individuals who spoke the most also contributed the most ideas. As such, it is not surprising to find that unbalancing participation equity significantly improved their idea generation performance. These combined findings suggested that unbalanced PERs might be beneficial in specific contexts and that team dynamics of effective virtual team idea generation might differ from those initially thought (Cauwelier, 2019; Duhigg, 2016; Google, 2015; Samrose et al., 2018).

The analyses also found that increasing a team's frequencies of the 4 meta-BiT verbal behaviours categories (initiating, reacting, clarifying and balancing) significantly improved their idea generation performance. Further reviews of the 15 BiT behaviour categories on the team's idea generation performance showed positive correlations for all behaviours. More specifically, the verbal behaviour categories of 'Proposing ideas', 'Building', 'Supporting ideas', 'Defending/attacking', 'Giving personal information', 'Shutting out', and 'Lightening the mood' were significantly correlated with increased team idea generation performance.

Given that the main objective of GAUT was to propose possible, creative and alternative uses for an item, it was no surprise that proposing ideas significantly correlated with the team's idea

generation performance. Analysing the teams' transcripts revealed that most sequences of interactions leading to the teams generating ideas frequently had a combination of ‘Proposing ideas’, ‘Building’ and ‘Providing personal information’ verbal behaviours. The transcripts also showed ‘Supporting’ (praising) verbal behaviours increased the occurrence of ideas being generated. This was also supported by the significant positive correlations between the frequency of ‘Supporting ideas’ on team idea generation performance and all three verbal behaviours listed above. (see Table 7-13 and Appendix D for an example transcript)

Table 7-13. Exercept from the transcript of a participant team doing the GAUT virtually

Participant	Content	Behaviour
003	Well it was a gift from…..	Providing personal information
001	(interrupts) Mugs can be a gift!	Shutting out, Proposing idea
003	Oh yeah! Good one!	Supporting Idea
002	As a decoration	Proposing Idea
002	Nice	Supporting Idea
002	As an adjective	Proposing Idea
003	Trap things in….	Proposing Idea
002	(interrupts) Like insects or spiders	Shutting Out, Building
002	Make a throw	Proposing Idea
003	Like a weapon	Building
002	Yeah exactly	Supporting Idea

The analyses found ‘Defending/attacking’ or ‘Lightening the mood’ verbal behaviours had significant positive correlations to the team's idea generation performance. The transcripts revealed that all ‘Defending/attacking’ behaviours exhibited in the study were said in jest (e.g., "*Have you been living under a rock? This is fashion!*"). They were typically followed up with similar "retorts" by the targeted person, leading to a few jokes (lightening the mood) being

made and leads to a new sequence of idea generation sequences described above (see Table 7-13 and Appendix D for an example transcript).

Reviewing the transcripts could explain how increasing 'Shutting out' (interrupting) verbal behaviours significantly correlated with the team's idea generation performance. It was revealed that 'Shutting out' behaviours were most likely immediately accompanied by verbal behaviour significantly beneficial to idea generation as listed above. This was further supported by the significant correlations between the frequency of 'Shutting out' behaviours and the other verbal behaviours improving idea generation. The findings on the team's BiT behaviours suggested that verbal behaviours typically considered "detrimental" may improve team idea generation if used appropriately in the proper context and situation.

Team dynamics for effective virtual team Innovation (Bridgebuilding task Baseline)

The analyses of the overall relationships between the team's dynamics on their innovation suggested a team's TIF had a slight positive non-significant correlation with their creative problem-solving performance. This supported hypothesis 2a, which predicted a virtual team's TIF had positive relationships with their innovative performance and was consistent with previous research findings showing that increased team interactions resulted in better innovation (Johnson et al., 2000; Li et al., 2018; Pisani, 2012; Warner et al., 2012; Zoltan, 2015).

The analyses also showed a more balanced team PER improved their innovation, supporting hypothesis 2b and previous research, which predicted that a more balanced team PER enhanced the team's innovation (Cauwelier. 2019; Duhigg, 2016; Google, 2015; Samrose et al., 2018). The analyses also showed a significant positive correlation between the team's TIF and PER, suggesting that increased team interactions naturally increased the imbalance of team member

participation equity. This means that a more balanced team PER could signal equal participation amongst team members or a lack of verbal interaction in general for virtual teams.

The results also showed that increasing the teams' TIF significantly increased their PERs, like the findings from the GAUT (see above). Although the direction of these findings was consistent with previous literature, their non-significance and minimal correlations suggested the presence of other team dynamics/factors affecting the team's bridgebuilding scores, such as team composition factors which could explain the current findings (Bear & Wolley, 2011; Bell et al., 2011; Wuchty et al., 2007). Future research should use the BiT coding system to examine the interaction between team composition on a team's dynamics and innovation.

The correlation matrix also highlighted that increased team frequencies of 'Disagreeing' and 'Shutting out' verbal behaviours negatively impacted BBT scores. Most unexpectedly, increasing frequencies of 'Proposing ideas', 'Building', 'Supporting people', 'Seeking task information' and 'Bringing in' verbal behaviours were shown to affect a team's BBT score negatively. This was unexpected as previous studies in the literature frequently found these behaviours to improve team effectiveness significantly and established good practice guidelines recommending the increased frequencies of these verbal behaviour categories (Bisby & Salas, 2019; Bui et al., 2019; Delice et al., 2019; Marlow et al., 2018).

A possible explanation for these findings could be found in the transcripts, which saw teams frequently proposed ideas that were normally met with support and praise from other members. If a team member asked about the other members' opinions about a proposed idea or procedure, it normally results in members showing support for the proposed idea. Even if other team members had previous reservations, they normally did not strongly challenge the status quo directly. The teams would then adopt said idea as their final choice even with disagreements or doubts about the ideas present (see Table 7-13 for an example). The events described above

seem to suggest the presence of group thinking, which is a known factor that significantly hinders effective team decision-making (Yilmaz & Peña, 2015).

Table 7-14. Transcript of a live-coded team during the bridgebuilding task.

Participant	Content	Behaviour
001	I don't know how we are going to support the middle of it	Giving Personal Information
002	What if we did….. Remember we were shown a demonstration (tutorial) where there were triangles with one (support) going up from the front and one going from the back?	Proposing idea
001/3/4	Yeah	Supporting idea
002	And connect it from this stop to the back side if it makes sense?	Proposing Idea
001/3/4	Yeah	Supporting Idea
004	We have to remove some materials to stay within budget	Disagreement
002	So what do you all think?	Seeking Task Information
003	I guess it is the best idea that we have so far?	Giving Task information
001	Let's try it then…..	Proposing procedure
004	Ok if you all say so……	Supporting idea

Although high-performing teams exhibited similar sequences of behaviours, they avoided group thinking by engaging in critical evaluations of proposed ideas or procedures before the team's final decisions were made. Team members typically followed up with procedural statements on the steps required to complete the task. 'Checking understanding' and 'Providing task/personal information' verbal behaviours were interspersed throughout this sequence,

where team members clarified doubts, made known their thoughts and feelings and aligned themselves to the goals set by the team. Transcripts analyses also revealed that teams with three successful bridge attempts utilised the knowledge gained from the tutorial session and gathered personal knowledge (e.g., memories of bridges seen before) to generate the solution to complete the bridgebuilding task.

Table 7-15. Excerpt of a transcript from another live-coded team with three successful attempts in the bridgebuilding task.

Participant	Content	Behaviour
001	Yeah, the lone middle beam seems weak	Giving Task Information
002	If we lowered the structure down a teeny bit, would that make a difference?	Proposing idea
003	Bring the whole thing down?	Checking Understanding
002	Yeah	Giving Task Information
003	I think if we brought the sides down and make it like an arch…. It may work?	Building
002	It does look like the Tyne bridge I pass by travelling back home to Newcastle	Giving Personal information
004	Hmm I don't know….	Giving Task information
003	Shall we try it?	Proposing procedure
004	I don't know, I have never done this kind of game before	Giving Personal information
001	Taking inspiration from the tutorial and Tyne bridge, let us add triangles in the middle bit?	Proposing Idea

Effectiveness of Feedback on Team Dynamics

The analyses for the GAUT indicated teams increased their TIF from the 1st to 2nd session irrespective of experimental condition. However, the paired sample test revealed that only teams receiving feedback had significantly higher second-session TIF than their first-session TIF. There were no significant differences between the team's TIF between sessions for the control teams. This indicates that teams receiving feedback had more substantial increases in their TIF in the second session compared to the control teams and is supported by the descriptive data. Regarding PER, teams receiving feedback had more imbalanced PER in the second GAUT session than the control teams, albeit non-significant. This difference could be explained by the significant correlations between a team's TIF and PER, suggesting that increasing team interactions would naturally imbalance their participation equity.

In contrast with the GAUT, the analyses for the bridgebuilding task showed no significant differences between the team's TIF and PER across the experimental conditions and time. The current findings could be explained after reviewing the transcripts and recordings of the participant teams. It was revealed that some participant teams would submit their second and third design to complete the task ahead of the allocated time. The verbal exchanges of said teams also highlighted their tendency to fixate on obtaining a better solution compared to those conducting in-depth evaluations of their current design. The combination of these factors resulted in them having lesser verbal exchanges than teams who fully utilised the allocated time provided. Future studies could consider the time teams used to complete tasks when investigating the relationship between team dynamics and performance.

Effectiveness of Feedback on Team Performance

The analyses for the GAUT indicated no significant differences between the team's GAUT performance across the experimental conditions and time. However, the results from the paired-sample t-tests showed providing team dynamics feedback significantly improved their subsequent idea generation performance. This could be explained by the descriptive data

depicting teams in the feedback condition were “relatively underperforming” in the first session compared to the control condition. The current study findings suggested that providing team dynamics feedback could effectively improve the performance of “underperforming teams” during creativity tasks.

The results also suggested that providing team dynamics feedback improved the team’s creative problem-solving performance for the bridgebuilding task. Although not significant, the team’s performance scores constantly improved after every task iteration for the feedback condition. The transcripts and recordings showed that teams in both experimental designs utilised various bridge designs that saw a wide scatter of performance levels for both experimental conditions and were supported by the large standard deviations of scores for both conditions.

Using the BiT Coding system to live code virtual teams

The current study provided evidence that the BiT coding app was effective in live coding the verbal interactions of virtual teams. Similar to the previous study, the video conferencing platform's “halo” effect, which highlighted current speakers and the ability to adjust the hearing volume of the conversations, helped the coders reduce the mental strain needed to code the teams accurately. Also, the study successfully showed the ability of the BiT coding iPad app to provide feedback to virtual teams being live-coded. This was done by virtually sharing the data summaries page with all participants through the video conferencing platform’s share screen button. The coders would then give them feedback, and the team could interact with the coder to request different information to be presented that would aid them in further reflection. The versatility of the BiT coding iPad app to be used in both F2F and virtual live coding is useful for educators and practitioners as it would reduce logistical preparations required to provide teams feedback.

Although the present study yielded promising results, the current study only utilized student teams with their cameras on. However, actual virtual team collaborations allow members have a choice to keep their cameras on and off during meetings. As such, future research should replicate this study with teams with their cameras off and teams that have a mixture of camera usage. This will help provide insight into the effectiveness of the BiT Coding system to measure and provide virtual teams feedback across a range of virtual meeting environments. It will also help provide more insights whether camera usage might impact a team's longitudinal communication dynamics.

Summary

In conclusion, the results suggested that the team dynamics associated with effective online team collaborations differed from those established for effective F2F teams. Hence, scholars and practitioners must account for these nuances to ensure optimal and effective online team collaborations. Further research is also required to examine the team dynamics of effective online collaboration in different contexts and periods to compare their differences with recommended F2F team collaboration guidelines.

The results also demonstrated that providing teams feedback about their communication profiles could potentially help improve their performance, especially for underperforming teams in the short term. Current results suggested that the feedback intervention has great potential to help modify team dynamics to achieve optimal team effectiveness for creative/innovative tasks. However, further research is required to see whether more extended collaboration periods are necessary to significantly modify team dynamics and performances.

The current study helped establish that the BiT Coding iPad app could be used to live code virtual teams' interactions accurately and that the generated data summaries could provide teams with feedback about their dynamics. The current study also obtained further insights into

the team dynamics associated with effective online team idea generation and creative solving performance. It evaluated the effectiveness of providing teams with team dynamics feedback on subsequent task team dynamics and performance.

Although some significant findings were obtained, the current study only consisted of multiple five-ten-minute sessions for the entirety of the experimental study. As such, future research must investigate whether similar results exist for longitudinal studies and whether interpersonal conversations for online teams might be beneficial in the long run, as suggested by previous team dynamics studies.

Table 7-16. Descriptive statistics and correlations of the team's frequencies of all 15 individual BiT verbal behaviour categories and ideas generated during baseline GAUT session

	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Proposing Procedure	0.06	0.24	-															
2. Proposing Idea	19.88	6.02	.22	--														
3. Building	4.59	4.04	-.01	.64**	--													
4. Supporting Idea	4.24	5.26	.18	.62**	.66**	--												
5. Supporting People	0.82	2.30	.08	.13	-.01	-.09	--											
6. Disagreeing	0.03	0.17	-.04	.00	.02	-.04	.86**	--										
7. Defending/Attacking	0.12	0.48	-.06	.34*	.31	.38*	-.09	-.04	--									
8. Checking Understanding	0.59	0.96	-.02	.24	.45**	.56**	-.14	-.11	.11	--								
9. Seeking Personal Info.	0.24	0.61	-.10	.21	.51**	.47**	.16	.22	-.10	.70**	--							
10. Seeking Task Info.	0.21	0.59	.13	.11	.37*	.18	-0.02	-.06	-.09	.21	.28	--						
11. Giving Personal Info.	3.82	3.75	.08	.50**	.59**	.79**	.09	.15	.32	.65**	.69**	.20	--					
12. Giving Task Info.	0.82	1.19	-.07	.26	.49**	.42*	-.06	.03	.14	.33	.35*	.61**	.41*	--				
13. Shutting Out	0.91	1.31	.21	.54**	.65**	.72**	-.16	-.12	.50**	.36*	.22	.30	.50**	.42*	-			
14. Bringing in	0.00	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
15. Lightening The Mood	1.29	2.54	.37*	.52**	.38*	.75**	.05	-.02	0.17	.48**	.35*	.28	.73**	.36*	.58**	-	-	
16. Ideas generated	20.06	6.31	.22	.99**	.64**	.65**	.12	.03	.40*	.27	.22	.15	.56**	.29	.59**	-	.60**	-

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Table 7-17. Descriptive statistics and correlations of the team's 15 individual BiT verbal behaviour categories frequencies and task score during the 1st bridgebuilding (baseline) session

	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Proposing Procedure	8.88	4.11	--															
2. Proposing Idea	9.03	4.44	.52**	--														
3. Building	8.38	8.40	.45**	.61**	--													
4. Supporting Idea	14.38	7.44	.17	.24	-.01	--												
5. Supporting People	0.88	1.68	.01	.30	.13	.19	--											
6. Disagreeing	0.21	0.77	-.32	.08	.00	.11	.32	--										
7. Defending/Attacking	0.09	0.38	-.11	-.07	-.15	-.25	.02	-.06	--									
8. Checking Understanding	5.56	3.52	.57**	.44*	.37*	.40*	.04	-.29	-.15	--								
9. Seeking Personal Info.	1.06	1.41	-.22	.31	.11	.08	-.01	.18	.22	.10	--							
10. Seeking Task Info.	5.03	3.95	-.13	.42*	.11	.17	.29	.32	.20	.27	.48**	--						
11. Giving Personal Info.	11.74	8.67	.21	.48**	.44**	.09	-.04	-.01	-.01	.52**	.47**	.37*	--					
12. Giving Task Info.	12.97	8.86	.33	.40*	.27	.25	.03	-.11	-.02	.70**	.13	.56**	.49**	--				
13. Shutting Out	2.15	3.08	.37*	.43*	.70**	.25	.32	.06	-.17	.44**	.03	.00	.41*	.31	--			
14. Bringing in	1.53	1.74	.33	.08	-.05	.12	-.09	.01	-.12	.41*	-.15	-.05	.21	.19	.08	--		
15. Lightening The Mood	1.88	2.99	.02	.49**	.37*	.29	.17	.16	.01	.10	.39*	.40*	.37*	.28	.34*	-.16	--	
16. BBT score	63.53	21.86	.20	-.17	-.18	.06	-.03	-.18	.07	.15	.06	-.06	.16	.13	-.13	-.12	.08	--

* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

Chapter 8 Discussion and Conclusion

Broad Overview

The main focus of this PhD was to investigate the relationship between team dynamics, creativity and innovation and how various factors such as virtuality and feedback could impact them. Thus this PhD conducted empirical studies that utilised a mixed methods approach via verbal behavioural coding plus transcripts and video recordings of the participant teams to measure verbal exchanges and interactions. This would provide more insights about the relationships between team dynamics, creativity & innovation and the effectiveness of providing team dynamics feedback.

However, the COVID-19 pandemic and lockdowns saw a restriction to F2F interactions and the early termination of the data collection for Study 2. There was also a lack of available research on the team dynamics of effective virtual team collaborations on video conferencing platforms and comparing their similarities and differences with F2F teams. This saw a new research focus on virtuality being added to the existing research questions to obtain more insight into the effects of virtuality on team dynamics, creativity, innovation and their interrelationships. The following sections provide a broad overview of the methodology and findings for each empirical study chapter.

Chapter 4:

The first empirical study of this PhD was a pilot study testing the effectiveness of providing team dynamics feedback to modify subsequent team dynamics and task performance. The study utilised a simplified version of the BiT coding app to live-code team dynamics and provided the data necessary to provide said team dynamics feedback. The study's findings indicated the team's TIF significantly correlated with their idea generation performance supporting previous research findings. However, it also showed that imbalanced team PER led to better idea-generation performance contradicting previous research findings. The study showed that

providing team dynamics feedback helped improve teams' total interaction frequency and PER of subsequent tasks. However, limitations of the chosen task prevented further analyses regarding the team's creative problem-solving performance.

The study also established the BiT coding app's ability to non-intrusively live code team interactions during tasks and provide a team's TIF, PER, and tallies of individual behaviours immediately post-session. It also highlighted the feasibility of practitioners and educators using the BiT coding app to obtain insights regarding the team's dynamics. Getting recordings and transcripts to obtain a temporal sequence and more context of the team's verbal exchanges was also recommended. Even with the current study's limited findings and small sample size, it showed that team dynamics feedback could increase TIF and balance PER of teams. This study provided a framework and recommendations for the subsequent empirical study.

Chapter 5:

This study aimed to replicate the previous study's findings and measure the effectiveness of providing team dynamics feedback using the 15 BiT coding system. More specifically, the study measured the relationships between team dynamics with the team's idea generation and creative problem-solving task performance. It also tested the effectiveness of providing team dynamics feedback to modify subsequent team dynamics and task performance. Recordings and transcripts of the teams were made to obtain insights about the content, context and sequence of verbal behaviours potentially related to team creativity and innovation.

The results showed that the relationship between a team's dynamics, creativity and innovation could differ based on the context and task requirements. The transcripts and recordings of the teams provided further context and helped identify the trends of verbal behaviours teams exhibited during both tasks. The current results and transcripts also suggested that beyond the quantity and equality of verbal interactions, the quality of said interactions was more crucial towards team effectiveness. Reviewing the teams' transcripts highlighted the importance of

team information exchange quality (Bui et al., 2019; Marlow et al., 2018) for practitioners to better utilise quantitative and qualitative measures to understand the relationships between a team's dynamics and performance.

.Although not significant, the results suggested providing team feedback about their dynamics could improve the balance of a team's PER as teams mainly focused on their PER during feedback sessions. This also explained the minor modifications to their TIF during subsequent tasks. The results also showed that increased team TIF would naturally see more imbalances in their PER regardless of the task. It was also recommended future studies should evaluate the team dynamics for entire task iterations instead of breaking one iteration into two halves done in the current study.

The COVID-19 pandemic and enforced lockdowns resulted in the early termination of data collection for this study, with challenges to proceeding with initially planned studies. Even with the current study's small sample size (ten participant teams), it showed providing team dynamics feedback could improve task performance and balance the PERs of teams. This study also provided insights for the subsequent empirical study, which investigated how relationships between team dynamics and creativity may differ based on virtuality.

Chapter 6:

The third study of this PhD investigated the effects virtuality and camera usage had on a team's dynamics and creativity. It also investigated whether the relationships between a team's dynamics and idea generation performance would differ based on virtuality. The study virtually replicated the methodology and creativity task used in the previous study. It compared the team dynamics and idea generation performance of participant teams across three experimental groups 1) Face to face, 2) Virtual (Cameras on) and 3) Virtual (Cameras off). As the Covid-19 lockdown restrictions prevented the recruitment of new face-to-face participant teams, the data

of the ten face-to-face teams obtained from the previous study were used in the current study's data analysis.

The current findings indicated that a team's dynamics were significantly related to team creativity, and increased team interaction frequencies significantly unbalanced the team's participation equity naturally regardless of virtuality. New insights were also obtained regarding the direction and strength of relationships between team dynamics and creativity for virtual video team collaborations and F2F teams. Also, camera usage did not significantly affect a team's dynamics and creativity except for their participation equity, which was related to the low frequency of interactions for teams with their cameras off.

The transcripts showed that virtual teams did not communicate as much as their FEF counterparts. However, they had more task-focused interactions, lesser interpersonal exchanges, and "chit chats", which could explain their better performance than F2F teams during the GAUT and the significant relationship between their TIF and creativity scores. It also indicated that virtual video conferencing platforms can replicate F2F meetings virtually but might require different team dynamics and processes to facilitate effective team idea generation. The subsequent empirical study was recommended to build upon the current findings and findings of Study 2 (Chapter 5) to evaluate the effectiveness of providing virtual teams dynamics feedback on subsequent task dynamics and performance.

Chapter 7:

The final study of this PhD further investigated the relationship between team dynamics, creativity and innovation for virtual teams with their cameras on. It also evaluated the effectiveness of providing virtual teams feedback on their subsequent team dynamics and performance during subsequent iterations of the experimental tasks. The study utilised a virtualised adaption of Study 2's methodology with the creativity and creative problem-solving

tasks. The study also compared participants' team dynamics and task performance allocated to either the control or feedback condition.

The analyses suggested the significance and directions of a team's dynamics on their creativity and innovation could differ based on task context and requirements. The analyses also showed a significant positive correlation between the team's TIF and PER regardless of the task, suggesting that increased team interactions naturally increased the imbalance of team participation equity.

For both experimental tasks, providing teams feedback about their team dynamics could improve theis subsequent session's dynamics and task performance across the various experimental conditions. More specifically, feedback was shown to improve a team's TIF across sessions, especially if they were not interacting much previously. The increased TIF will help improve the team's effectiveness given the strong correlations between a team's TIF and their task performance. However, practitioners and educators should note that increasing a team's TIF would subsequently lead to a natural imbalance of their PER due to their significant correlations. As such it should be encouraged that teams especially those meeting virtually should focus on increasing their total interactions before achieving a more balanced participation equity rate.

The analyses for the bridgebuilding task showed no significant differences between the team's TIF and PER across the experimental conditions and time. However, this could be explained by the transcripts and recordings for the creative-problem solving task. It showed some teams completing the task ahead of the allocated time either from a lack of in-depth evaluations of their current solution or further discussions with their team. The findings on the team's BiT behaviours suggested that verbal behaviours typically considered "detrimental" may improve team creativity and innovation if used appropriately in the proper context and situation.

Implications and Contribution to Knowledge

The findings of this thesis provide several contributions to the organisational psychology and team dynamics literature. The literature review revealed several issues highlighted by scholars which affect the understanding of the relationship between team dynamics and effectiveness, such as inconsistent findings and a lack of accurate measures and interventions to improve team dynamics (Bui et al., 2019; Marlow et al., 2018). The COVID-19 pandemic and issues reported about the difficulty in fostering effective virtual team collaborations also highlighted the relative lack of research on effective team dynamics for virtual collaborations and the comparison of effective F2F and virtual teams dynamics (Acai et al., 2018; Singh et al., 2021; Waizenegger et al., 2020). The combined implications and contributions of the four empirical studies are discussed below.

Insights of using the BiT coding system in practice

The literature review highlighted contradictory findings regarding the relationships between team dynamics and effectiveness (Bell et al., 2011; Bui et al., 2019; Stahl et al., 2010; Thatcher & Patel, 2011). This led to calls for researchers investigating team dynamics to use a method that can accurately measure and differentiate between the different verbal behaviours exhibited during team verbal exchanges (Bui et al., 2019; Marlow et al., 2018). As seen in the literature review on effective feedback (Chapter 2), there are multiple benefits to teams receiving immediate short-cycle feedback, such as increased learning and behavioural change (Farley et al., 2018; Gabelica et al., 2012). The two factors above led to this researcher's decision to incorporate live verbal behaviour coding and analysis. This would allow quick and accurate quantification of a team's dynamics into different behaviour categories/types. It also allowed for the rapid generation of data summaries regarding the team's interactions, which are integral and crucial elements to providing short-cycle feedback.

While evaluating the available coding schemes and systems (see Chapter 3), the current

researcher noted a relative scarcity of good practice guidelines and issues to consider when choosing live verbal behaviour coding as a research methodology or intervention. This scarcity was unsurprising, given that most schemes and systems adopt a retrospective analysis approach to measure and quantify a team's interactions and dynamics (Brauner et al., 2018). Hence, the following sections will provide insight into the good practice guidelines of using Bit, based on the researcher's experiences, observations, and notes. It will also discuss the benefits and technical, practical and logistical issues to consider when using the BiT coding system and iPad app during live coding of a team's interactions.

The technologically advanced iPad app version of the established and validated 15-BiT coding system allowed unprecedented portability compared to similar desktop-based interaction analysis systems (Brauner et al.,2018; Farley et al., 2018). The BiT Coding app's portability did enable this researcher to easily live code team meetings and generate an overall summary and initmate breakdown of the team's behaviours immediately post-session. The unprecedented richness of the summaries' details enabled this researcher to uncover the sequential finer processes and structures underlying effective team task performances and meetings.

At the same time, the data summaries were used by this researcher to immediately provide teams short cycle feedback about their team's dynamics post-session. To this researcher's knowledge, this PhD research project is the first of its kind to use a portable, technologically aided but non-AI-based live verbal behavioural coding system (Brauner et al., 2018; Samrose et al., 2018) to accurately measure a team's dynamics during sessions and use its data summaries to provide teams with high-quality short-cycle feedback that encouraged reflection (Farley et al., 2018).

During the empirical studies, the BiT coding system has effectively measured all the team's

interactions within a task session, providing users with immediate summaries of the team's interactions and dynamics. These were invaluable to understanding the relationships between a team's dynamics and their effectiveness and how it could differ between F2F and virtual teams. However, evaluating and comparing the quality of content within said team interactions and verbal exchanges is also important. Thus having transcripts and recordings of the teams would be invaluable in allowing the coders, teams, and researchers to obtain more context, uncover nuances, identify differences between teams, and examine how different factors (e.g., virtuality) affected the teams' information exchange during meetings.

The BiT coding system was originally created to educate and provide students in higher education the necessary behavioural skills to work and communicate effectively in teams (Farley et al., 2018). The successful use of the BiT coding system and app within the four empirical studies of this PhD provides support to use it as an educational and training tool. Alongside the BiT coding system, it is suggested that researchers and practitioners obtain recordings and transcripts of teams to help identify trends, temporal sequences and differences in the quality of interactions exhibited by teams. Providing transcripts and recordings to students and supervised teams would allow for further retrospective reflection and may see increased change in subsequent sessions. This may also help observers and researchers identify previously undetected trends in the team's interactions that may improve the quality of feedback provided to the teams, especially in a longitudinal setting.

Although primarily used for live-coding, the BiT coding system can also be used in retrospective coding of teams. The ability for the BiT coding system to be used in both live and retrospective coding allows educators and trainers more flexibility in the method of coding and provision of feedback. Further research should investigate the combination of live and retrospective coding and feedback to teams to identify the feedback effectiveness and magnitude of change.

Technical, Practical and Logistical considerations

This section will discuss technical, practical and logistical considerations when using live verbal behavioural coding within a research design or as a practical intervention to improve team interactions and dynamics via short-cycle feedback.

Training time and resources

The first factor to consider is the training required for the coder to be proficient with the live-coding system (BiT in this context) and the logistics required (location, iPads, team schedules, etc.). It must be noted that training coders on a scheme/system need a significant investment of time from the trainers and coders to achieve proficiency (Brauner et al., 2018).

Although the training course for BiT coding is considerably shorter than the other available systems, it still requires 20 training hours to be proficient (Brauner et al., 2018; Farley et al., 2018). This translates to at least three days of intensive training on the material within the BiT coding app/training manual and attending a face-to-face facilitator-led training session. If coders do not meet the passing requirements, more time must be spent on remedial training to achieve proficiency. Hence, researchers and practitioners must plan and account for the time required to train coders within their research design or intervention plan.

Environmental and Virtuality Settings

Another factor to consider is the environment and virtuality setting where the teams will be coded. The nature of verbal behaviour analysis requires coders to interpret verbal interactions and code them into different categories. However, doing it live requires coders to identify a speaker, interpret said interactions, and make split-second decisions on the appropriate categories they belong to, given the next exchange would follow almost immediately. Unlike retrospective analysis, there is no stop or rewind function to repeat the previous interaction

and reconsider that decision, resulting in a heavy cognitive load on the coder.

This means that prolonged or intensive, fast-paced team interactions could lead to coders experiencing fatigue. This researcher suggests that the length of coding sessions should be around one hour and the scheduling of coding sessions be spaced apart to reduce coder fatigue. Also, the environment could lead to unwanted sounds and distractions that may disrupt the coder's ability to hear the team's verbal exchanges adding to their cognitive load, especially for F2F teams. Hence it is recommended that live coding of teams should be conducted in a quiet room to reduce the mental strain needed to hear the team's exchange.

One way to mitigate the issue of coder fatigue is to conduct live coding with virtual teams via video conferencing platforms such as Zoom/Teams etc. This is because the platform would readily identify the individual speaking via a "halo" surround effect, and the high clarity and volume help reduce the coder's cognitive load. This reduction in cognitive load benefits the coder by allowing more focus on interpreting the spoken content, improving the accuracy of the coded behaviours. The added functionality of video conferencing platforms to record the entire session would also allow for the production of transcripts and further retrospective analyses.

Familiarity with the team's culture and language

Another few factors must be considered when selecting the coders to live code a team's verbal behaviours and interaction. They are mainly the coder's familiarity with the organisational/societal culture and command of the language used by the coded team (English in this context). Given that the coder conducting the live coding is the primary source of interpreting the team's interactions and the "gold standard" (Farley et al., 2018), familiarity with the different situational contexts and possible colloquial terms (e.g., *"This bridge looks wonky to me*") or phrases (e.g., *"Oh TGIF! we can nick this straw to do strawpedos later at*

the social after this") is required. This is even more pertinent and important for coders who are non-native and/or lack familiarity with the coded teams' societal/organisational culture and language.

Although these phrases are commonly used and easily understood by coders native or very familiar with the language and culture of the United Kingdom, non-native coders might have to spend additional time processing to interpret those phrases to understand the context and statements accurately. Although not present within the studies of this PhD, a similar assumption can also be made for the coder's familiarity with the team's organisational culture or task context of the coded teams. This could include everyday tasks and procedures and commonly used acronyms of (e.g. KPI, ROI, NGO, QA), which could impact the interpretation and accuracy of unfamiliar coders without additional help or understanding. As such, it is suggested that live coders should have a good command of the language spoken, be familiar with the social norms/phrases and be trained to be knowledgeable about the organisational and task context of the coded teams. The next section would be discussing the combined empirical findings from the previous studies.

The relationships between team dynamics, effectiveness and virtuality

Consolidating the BiT data summaries and identifying verbal behavioural trends within the transcripts of participant teams offer further insights into the relationships between team dynamics, creativity and innovation. This could help address the contradictory results of the current literature on factors affecting team dynamics. Previous research on team dynamics has generally suggested that increased team interactions and more balanced participation equity are positively associated with team creativity and innovation (Bui et al., 2019; Li et al., 2018; Marlow et al., 2018; Warner et al., 2012; Zoltan, 2015).

However, some studies reported contradictory findings, which could be attributed to the lack

of accounting for the task and environmental contexts or other interrelated factors (Bell et al., 2011; Stahl et al., 2010; Thatcher & Patel, 2011). As such, the thesis utilised the BiT data summaries, task performance scores and transcripts of the participant teams to obtain further insights into the relationships between team dynamics, creativity and innovation.

The current findings support previous research findings that a team's dynamics were associated with the team's creativity and innovation. However, their relationships could differ based on environmental factors, task context and requirements. The results indicated that increased TIF significantly benefitted a virtual team's creativity, while increased PER positively associated with their creativity. However, the relationships between TIF and PER on team creativity for F2F teams were inconclusive due to the contradictory findings of Studies 1 and 2 (see Chapters 4 & 5). The results of Study 3 (See chapter 6) also suggested virtual teams could outperform F2F teams and had lesser interpersonal communication compared to F2F teams. It also indicated that camera usage, at least during short tasks, did not significantly impact the team's ability or communication.

Regarding the relationships between team dynamics and innovation, the results of Studies 2 and 4 (see Chapter 5 and 7) suggested that increased team TIF and more balanced PER benefited a team's creative problem-solving and innovation performance, which were consistent with previous literature. However, the non-significant correlations between these two factors and their performance scores suggested other factors might affect their relationships, such as team composition and diversity (Bear & Wolley, 2011; Bell et al., 2011; Wuchty et al., 2007). Although there were no direct comparisons between F2F and virtual teams during this PhD's empirical studies, the correlation strength difference suggested virtuality might impact the dynamics and effectiveness of the teams. Further research should obtain more insights into the effects of camera usage and compare the interactions and performances of F2F and virtual teams.

Nevertheless, the combined findings of the empirical studies reinforced the importance of a team's dynamics and interactions on task performance and effectiveness. The relationships found across different task and environmental contexts during the empirical studies supported the notion that one size fits all approach regarding team dynamics should be avoided (Marlow et al., 2018; Murase et al., 2012). Educators and practitioners should teach teams about the traits and behaviours of high-performing teams and more importantly, methods to achieve high-quality information exchange across different task contexts. Familiarising teams with both aspects would encourage good communication habits and improve effectiveness across various task contexts.

The effectiveness of immediate short-cycle team dynamics feedback

Using the data summaries to provide teams feedback about their dynamics addresses another issue highlighted in the literature: a lack of interventions to improve team dynamics (Marlow et al., 2018). Previous research investigating the effectiveness of feedback found it to enhance subsequent team dynamics and performance. However, most of the studies used the team's performance data to provide feedback (Gabelica et al., 2014a, 2014b; Konradt et al., 2015; O'Neil et al., 2018, 2020) or had a period passed before feedback was given, which could have reduced its effectiveness (Farley et al., 2018; Thornock, 2016).

The empirical studies address this gap within the literature by evaluating the feasibility of using the data summaries generated by the BiT coding app to provide teams with immediate feedback post-session. It also assessed the efficacy of team dynamics feedback to improve subsequent task dynamics and performance. The findings suggest that feedback could increase the team's awareness of their interaction patterns, leading to changes in their dynamics and task performance during subsequent sessions. However, the general non-significance of the results indicates the presence of other team factors at play that might impact the effectiveness of the feedback, such as team composition and diversity.

Even with the non-significance, the current findings show that analysing and providing teams feedback about their dynamics and verbal behaviours will be a good training tool, especially in educational settings. More importantly, the studies provide evidence that giving short-cycle feedback to teams in both F2F and virtual environments encourages reflection and is shown by changes in their interactions during subsequent sessions. Although the current studies suggest feedback could be more effective in improving underperforming and interacting teams, further longitudinal studies are required to see if its effects are sustained in the long term.

The aim of providing feedback is to encourage reflection among the team members about their behaviours to effect change in their subsequent interactions and sessions (Farley et al., 2018). Incorporating formal teaching sessions to familiarize teams with the various verbal behaviours uttered during sessions would help complement and increase the effectiveness of the feedback given post-sessions. Implementing both teaching sessions and BiT coding of teams would help address some issues with teaching effective teamwork, namely the lack of accurate measures and tools to provide effective short-cycle feedback to said learners (Farley et al., 2018).

Utilizing the GAUT and variations of team creative problem solving tasks used in this PhD is also recommended as it is a fun and time efficient method to obtaining a baseline about the team's dynamics. This could be utilized at the start of sessions or education modules to also foster interaction and communications within teams. The coding done during this sessions would allow team members to reflect and potentially change their team's dynamics during subsequent sessions. The baseline summaries could also help educators and practitioners chart the team's progression through the project or course and allow adjustments to the given feedback to suit the team's current exhibited dynamics.

Limitations and directions for future research

This section summarises the common limitations and potential research directions for team dynamics research outlined in the discussion sections of the four empirical study chapters (Chapters 4-7).

The current study utilised a random sampling method which did not control for the team diversity composition of the current participant sample. The demographic data showed that most participants were female and saw a lot of all-female teams. Similarly, team personality, cultural, and other diversity factors could have affected the current results. Previous studies have found team diversity composition to significantly affect a team's dynamics and performance, which might have impacted current findings (Bear & Wolley, 2011; Bell et al., 2011; Wuchty et al., 2007). Further research could investigate the interactions between team composition and its relationships with team dynamics and effectiveness. This would help provide additional insights required to understand how they could impact the interactions of a team.

Another limitation is the current studies' single session and short experimental task length, as organisational teams meet multiple times during collaboration for a given project. The current studies yielded exciting findings and insights about the team dynamics and performances for F2F and virtual team idea generation and creative problem-solving collaborations. However, further research is needed to establish whether similar results will be seen from long-term team collaborations or tasks with longer durations. This would help validate current findings and develop good practice guidelines for effective F2F and virtual teamwork. Finally, the sample size for all the empirical studies was relatively small. It is expected that conducting the current studies with larger sample sizes would discover significant relationships that may have remained undiscovered.

It is also to note that the current studies only focused on the verbal behaviours uttered by the teams during the experimental tasks. However, previous research has highlighted the importance of the non-verbal behaviours of the team members that simulteanously occurs with said interactions, as it could impact the team's effectiveness and be an alternative way of communication (Google, 2015; Gordon et al., 2006; Samrose et al., 2018). This is also reflected within the video recordings of the teams during the tasks where team members waved or pointed to specific points or made funny gestures to each other that were not coded.

Nonetheless, it is vital to highlight the disparities between verbal and non-verbal behaviours, as each necessitates distinct sampling and data collection methods. Verbal behaviours typically adhere to a sequential structure and derive their meaning and significance from the task, context, and preceding verbal exchanges (Brauner et al., 2018). Conversely, non-verbal behaviours coincide with verbal interactions, requiring separate coding, sampling, and observational approaches to discern their significance within a diverse array of conversations, tasks, and contexts (Brauner et al., 2018).

In future analyses and research, incorporating a dedicated coding system for non-verbal behaviours or conducting retrospective analyses of video recordings and transcripts could prove advantageous. These techniques can delve deeper into unravelling the connections and interplay between verbal and non-verbal behaviours observed within teams during sessions, shedding light on their influence on team dynamics and performance across various tasks, contexts, and meeting environments.

It is acknowledged that the current participant sample comprises only student teams, which may not represent how professional work teams interact during similar task contexts (Fredrick, 2008). As such, the lack of authority over team members, the pursuit of academic success and emphasis on harmonious working and interaction amongst each other are some factors that

might affect their interactions within the tasks (Fredrick, 2008; Riebe et al., 2016). As such, future research should replicate the current experimental studies with professional work teams to identify differences in the interactions and dynamics of students and professional work teams. This would help educators bridge the gap between theory and practice and improve the pedagogy to teach students teamwork skills.

Dissemination of Research

Throughout the PhD, the researcher disseminated the findings of each study with practitioners through presentations at national teaching and internal departmental conferences. The researcher aims to engage a wider audience by disseminating the findings through written articles and journal publications.

This researcher also gave lectures, seminars and masterclasses about effective virtual teamworking for the BSc and MSc Psychology curriculum at Edge Hill and Cardiff University's School of Psychology. This researcher is also engaged in a project with Cardiff University's School of Computer Science to integrate the findings of this PhD. This project has two aims, the first is to formally teach students about effective team dynamics across different virtuality environments to improve communication and reduce team conflicts during a longitudinal team project. The second aim of this project is to investigate the effectiveness of retrospective analysis of their verbal interactions and increase reflectiveness within their written journals about their individual and team's dynamics. Table 8-1 below outlines the rersearcher's dissemination efforts.

Table 8-1. Outline of the dissemination efforts of the study findings of this PhD.

Chapter	Conferences & Presentations	Publication status
4	N/A	N/A
5	Presented at Edgehill and Cardiff University (internal curriculum presentations)	In preparation for journal submission

6	Presented at SOLSTICE and CLT Conference, 28th – 29th June 2022 Presented at R.A.I.S.E Conference, 10th - 11th September 2022 Presented at Cardiff University School of Computer Science (internal presentation)	In preparation for journal submission
7	Presented at Cardiff University School of Computer Science (internal presentation)	In preparation for journal submission

Conclusion

The four empirical studies conducted in this PhD have shown the feasibility of using verbal behavioural coding and analysis to better understand a team's dynamics and performance. In effect, the BitT coding system and iPad app is an effective and user-friendly methods to obtain detailed information about the quantity and equality of the team's interactions. The data summaries generated are essential to providing teams with immediate high-quality short-cycle feedback and understanding the relationships between team dynamics and effectiveness for both F2F and virtual teams. The BiT Coding system is also recommended to be used by both educators and practitioners as an educational and training tool given its ease and flexibility of use for live and retrospective coding of a team's verbal interactions.

The results also highlighted the importance of combining qualitative and quantitative measures to obtain further insights into the relationship between a team's dynamics, creativity and innovation. This PhD has also provided a framework for practitioners and educators to use the above data to give teams feedback about their team dynamics. More importantly, it established that team dynamics feedback could improve the team's subsequent team dynamics and task performance, especially for underperforming teams.

During this PhD, the Covid-19 pandemic and lockdowns led to the sudden and unprepared shift to conduct teamworking and collaborations virtually. The lack of empirical studies comparing the team dynamics and performance of face-to-face and virtual video team collaborations led to challenges in facilitating virtual team collaborations. The PhD attempted to address this gap with results showing relationships between team dynamics, and idea generation could differ based on virtuality. As organisations are increasing workplace virtualisations to meet employee requests, further research is required to obtain additional insights and validate current findings in longitudinal studies.

The combined results of the current studies have provided insights that would aid in establishing good practice guidelines for both face-to-face and virtual team collaborations. The insights obtained from this researcher's experience would help improve the BiT coding system and things to consider when planning to use live verbal behaviour coding. The next step of this work involves expanding the current methodology and using BiT coding to understand the effects of team composition factors and their relationships with team dynamics in longitudinal tasks and environments.

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Appendices

Appendix A – Description of The 4 meta categories and 15 individual BiT Behaviour Categories

Initiating Behaviours: behaviours related to idea and suggestion creation	
1. ***Proposing Procedure***:	The speaker puts forward, directly or indirectly, an actionable new procedure or team organizing method that relates to how the task or meeting output will be achieved.
2. ***Proposing Ideas:***	The speaker puts forward, directly or indirectly, an actionable new idea that relates to the task or meeting output being discussed.
3. ***Building:***	The speaker puts forward, directly or indirectly, an actionable new suggestion that obviously develops or extends another person's proposal.
Clarifying Behaviours: behaviours that improve a team's common understanding	
4. ***Supporting Ideas****:*	The speaker tells others present she/he agrees with or supports the ideas or task-related opinions of another team member.
5. ***Supporting People:***	The speaker expresses personalized support to another person present, for their contributions, efforts, or abilities.
6. ***Disagreeing****:*	The speaker directly disagrees, raises objections or puts up obstacles to another person's proposals or opinions.
7. ***Defending / Attacking****:*	The speaker directly attacks, negatively evaluates another person, or defensively blames others.
8. ***Checking Understanding:***	The speaker asks questions that check whether there is a shared understanding of another team member's contribution, or of what has been discussed or decided by the group.
Reacting Behaviours: behaviours that establish agreements and disagreements	
9. ***Seeking Personal Information:***	The speaker asks others present about personal facts, activities, anecdotes, concerns or feelings.
10. ***Seeking Task Information:***	The speaker asks other questions about task-related facts and opinions, and things indirectly relevant to doing the task.
11. ***Giving Personal Information:***	The speaker discloses information about personal facts, activities, anecdotes, concerns or feelings.
12. ***Giving Task Information:***	The speaker gives facts, opinions, and clarifications relating to the task or the broader work of the team, to other team members.

Process Behaviours: behaviours that balances team participation interaction rates	
13. ***Shutting Out:***	The speaker excludes another person or reduces their opportunity to participate.
14. ***Bringing In:***	The speaker invites task-related contributions from a member of the team who is not actively participating in the discussion.
15. ***Lightening The Mood:***	The speaker tells jokes, or makes humorous interjections.

Appendix B: Example of a fully coded Transcript of a team doing the GAUT from Study 2 – Chapter 5 - (Numbers correspond to the associated category in Appendix A)

Who	Spoken text / Action	Behavior Cat.
Researcher	First item is a pen	
	Official start of Activity	
004	So…. alternate uses of a pen (laughs)	15
001	I can't think of any right now	11
003	We've got one…. To write with	2
004	It is a good use though..	4
002	We can use it to like… scratch your back…	2
003	It's what I do too!	11
004	Some people do that too	4
002/001	Yeah	4
001	Or like you know, some of them devices where you have to reset them by pressing a button?	2
002/004	Yeah	4
004	To reset the devices, you need the right size to do it	3
001	Or like to press small buttons	3
003	What else?	10
003	I guess you can stack the pens?	2
003	But what will you stack the pens for?	10
001	(laughs)	
003	Do you know what I am saying?	8
004	I think I know what she is saying	11
004	Do you know those felt tip pens where you can stack the covers together?	3
003	Yeah that is what I am saying	11
001/002	Ohhhh….. yeah…..	4
003	(simultaneous interruptions) so… to use as a toy that can stack…..?	13,3

004	(simultaneous interruptions) so like if you stack them together you can do all kinds of things	13, 12
003	What should I write?	10
004	Hmm… to play with I guess?	12
003	You know what I am saying right the type where you have caps similar to this (marker) that can stack	8
004	Yeah	12
004	Well you can write down to play with…. Too?	1
001	Yeah……. You can use a pen to like punch holes in multiple pieces of paper….?	2
004	Yeah	4
002	Yeah	4
002	like instead of having to find a hole punch…	3
002	I do that sometimes too	11
004	(to 003) use as a hole punch	12
003	Use…. As …. A …. Hole… punch…	12
003	Is it hole, like as in H.. O… L… E..?	8
002/004	Yeah	12
003	For some reason I cannot process it in my head	11
004	I guess you can use it to keep paper together I guess?	2
001	I was just about to say that!	11
001	Like a paper clip!	3
002	Yeah	4
003	(interrupts) So you mean like this bit (taking up a pen cover)?	13, 8
003	So essentially those like this with a longer edge?	8
004	Yeah	12
003	So it is listed to be used as a paperclip….	12
002	Well I don't know….. if it is a use?	11
002	But I guess you can put it behind your ear…..	2
004	(Interrupts) you mean like this? (gesturing)	13, 3
002	Yeah like… not sure what to call it	12

003	Well I don't know…	6
003	Because I usually put mine (pen) in my hair sometimes.	11
002/004	Oh yeah!	4
002	(interrupts) Some people put it in their hair….	13, 3
003	(interrupts) like this… (gesturing).. so… like…	13, 3
002	So just put…to keep your hair up	2
004	Yeah…	4
003	You know like sometimes people will do….	8
004	(interrupts) yeah	13,12
002	So like to keep up your hair	12
003	Hmm how many have we got?	10
003	1..2..3..4..5..6…7…	12
004	You know some people actually use the pen for emergency tracheotomies	2
004	You know like to punch a hole in someone's throat to help them breathe	3
003	Yeah you mean like this right… (gesturing)	8
003	You know that was actually shown on some tv show that I watch	11
003	You know there was this tv show I watched called xxxx.. which showed it.	11
003	Didn't they do another one…. Called…	9
004	(interrupts) I don't know but I know it is definitely shown on tv	11
001	(interrupts) well let's guess put the answer down first	1
004	Since we don't how to spell, let us just put it as emergency aid tool for breathing	1
003	For emergency… use…	8
002/004	Yeah…	12
003	Well I guess we can add in for throat	3

004	Yeah as a emergency breathing tool for throat	4
002	We have got writing…..	12
003	mmhmm	12
002	People like to draw on their hands don't they… like making up something… or like a to do list….	2
002	But I don't know if that is considered normal or a use?	11
003	It is more of that one… (pointing to another listed use)	12
001/004	Yeah	4
004	I think we should branch it out… (from said use)	1
002/003	Yeah	4
001	I can't think of any more ideas with pens	11
002	Oh you can use it as like a pointer! (gesturing)	2
003	Yeah	4
004	And like people use it like a fidget toy!	2
003	(to 002) (interrupts) So you mean like using to point at things on a board?	13, 8
002	Yeah	12
003	Hmm I think we are doing quite well	12
004	For a pen.. yeah	15
004	So I was saying you can use it as a fidget toy	12
004	So like I will just sit there and then take my pen and start to use it like that (starts fidgeting with pen in hand)	11
003	Well its starting to look like we have a lot of uses for a pen	12
004	I cant think of more….	11

002	People who are trying to stop smoking will use it to like… just hold (gesturing similar to cigarettes)	2
004	Oh yeah…	4
002	So like can put as smoking distractor or something?	12
004	They can use it like a placehold as well	3
002	Yeah	4
003	Got it	12
002	And I think that is it….	11
003	I think we really got a lot of uses	12
	End of activity	

Appendix C: Example of a fully coded Transcript of a team doing the Bridgebuilding task from Study 2 – Chapter 5 - (Numbers correspond to the associated category in Appendix A)

Who	Spoken text / Action	Behaviour Cat.
	Official start of Activity	
001	Alright basically, I was thinking about how you can out the straws inside of each	2
002	Yeah! I was thinking of that	4
003	Yeah…	4
001	But I feel like if we are going to make it sturdy, we will like have to wrap it and tape like 3 or something together and then….	3
002	Interrupts	13
002	So, put them… so something like	3
002	So, put them through like that (shows with straws) 3 or 4 times like that and cello tape them up all together?	3
001	Yeah…	4
002	So, are we doing this across the table?	10
001/003	Yeah…	12
002	So let me get this one in here….	1
001	Ok…	10
001	So unstable	12
002	Because there is always someone sat at the table trying to shake.	7
001	Argh this is super hard…	11
001	Oh I got it! (shows completed prototype)	12
002	Why don't you keep on going while I cello tape these (completed prototypes)?	1
All	All building	-
001	Shall I just keep making them (prototypes)	10
003	Yeah…. Can do….	12
002	Right we need to put three of them (gesturing)	1
001	Oh like three	8

002	Like that (gesturing) and that….	3
002	So that there are three straws in each… just to make sure…	3
001	Oh okay so like…. Tape them together…	8
002	Yeah…	12
001	So I am put in one more (straw) in all of them yeah…	10
002	Yeah..	12
003	I just realized all the tape (cut individually and put on the table side) are stuck together (laughing)	15
002	Would you please… urghh.. don't let them stick together…	15
001	(Laughs)	-
002	Could you please put them further apart instead of side by side….	1
003	Yeah I am going to do that now	4
002	You can do them(tape length) short, like only going to use this long (shows 003 sample length)	2
001	(Puts another completed straw prototype down)	-
002	Fab… I am just managing the resources…	15
All	(Laughs)	-
All	Building	-
003	(To 002) I am going to use that (scissors) then	**12**
All	Building	-
001	I am just going to keep making the sets of them (linked straws)	1
002	Yeah….	12
001	And then how are we going to do it like once we have got like loads…..	10
002	Interrupts	13
002	So we have like a few sets (linked straws) and we have them across like (gesturing) I don't know, a set of like six or seven there (gesturing)	12
001	Yeah….	4
002	A set of six or seven there (gesturing) and we can do it like do something on the sides to balance it and the middle bits are like (gesturing)	3

001	Got you…	4
All	Building	-
001	Do we need like… a foundation for it or like…	10
002	Interrupts	13
002	No no no…	12
003	Not needed…	12
001	No.. But can we like make one?	6,2
002	(shakes head no vigourously)	-
002	We don't even get cello tape, in the cadets, well they do but… they only give us like a little tiny bit..	11
002	And… (to 001) my straw came out (shows straw that fell out) (laughing)	15
001/003	(Laughs)	-
002	Sorry!	11
001	Its alright..	11
003	Honestly…? honestly…? 002… destroying things already…	7
002	Its hard for me to tape this two together….	7
All	Building	-
001	So like someone going ask what did you do in school today?	11
001	Oh built a straw bridge today	15
002/003	(Laughs)	-
002	You can also say we are paying 9 and a half grand to come up with a creative idea	15
003	Found uses for bricks and pens and built a bridge…	15
002	(false stiletto voice) oh we can do first aid with a pen	15
003	(Laughs)	15
002	I am actually terrified if I had to do that… although I am trying to do this.	11
003	I mean how can you not notice this one (piece of tape) here (pinky that is stuck out)	7
002	How can I just (incomprehensible)	7

002	I do now remember that they sent out an email saying that this is going to be really and exciting and (incomprehensible)	11
003	Oh… no…	11
001	Oh yeah they do this quite a lot	**11**
All	Building	-
002	So if we do like… six or seven… (picks up seven connected straws)	2
002	There is no way we are going to get that many….	12
002	How much time do we have left?	10
003	10 minutes	12
001	Do you want me to keep making these straws?	10
002	Yeah	12
003	Tell me if you need longer ones (pieces of tape)	1
001	I will just keep going with these (making straws)	1
001	And if like you want to start assembling the thing, that's fine	1
All	(building)	-
	Long period of silence	-
	Sound of Helicopter flies over head	-
003	(incomprehensible joke)	15
All	Laughs	-
003	I'm joking…	11
002	(straws connected straws together)	-
002	Alright now that is one side… (one of the bridge)	12
002	now if we can get some tape	1
002	(to 003 struggling with the tape) It will be easier from the end	1
003	Well I found the end…. (tape roll)	12
003	Just getting the end out…!	12
003	See… I got it out…	12
002	Cut it (the tape) abit longer (in length)	1
002	Yeap…	4

002	(Takes tape and starts taping the connected straws together)	1
All	(building tasks)	-
001	And how is it (the connected straws) going to stay up?	10
002	I dint think that point up	11
All	(giggles)	-
003	We can use cello tape around it….	2
002	You what sorry?	8
003	We can use the cello tape and roll it up…	3
002	Yeah, but when I did it for the last time around and I ended up sitting up with garbage.	11
002	To be fair all the (incomprehensible) are quite expensive ….	11
003	Why would you know these?	9
002	I do it with the cadets	11
002	Which is really funny because as part of the cadets, we do it like as part of our competitions.	11
002	So sometimes I would just go around and accidentally help them win, which will make them think I am favoring a group and helping them win.	11
003	Do you need another long piece (tape)	10
002	(continues and finishes wrapping current tape around connected straws)	-
002	(Puts completed straw platform on table)	-
003	(Points scissors towards 002 in a well done manner)	-
002	Smashing…	5
001	Right so is that one of the sides?	10
002	Yeah	12
001	Right so we are going to have one (waves completed straw platform) and one (on the other side) and then like… (hovers straw platform in middle)	12
002	No just across the table…	6
001	What do you mean?	8
002	So, we pull the tables across and we put one (straw platform) here, one there and one over there.	3

001	Ohhhhh…. Right….	4
002	We cannot anchor it on to the table.	12
001	So that means we are not able to hold it as well?	8
003	Yes, task said it also has to be unsupported	12
001	(Tries to make a bridge arch with the straw platform.)	-
002	I will just do that (holds straw prototype)	1
003	We have seven minutes remaining	12
All	(gasps)	11
002	Oh, that's so pressuring	11
001	Yeah but how are we going to do this like that?	10
002	Just do it like that (shows straw prototype)	12
001	So I will have one here (holds straw platform), make another one there and just do there (holds it in middle of air)	8
002	Why don't you do it like that (shows own straw support prototype) and just put it (straw platform) on top?	12
002	So put another one of this (straw support prototype) across and just put this (takes straw platform from 001) on top (of own straw support prototype)	1
001	Oh! Ok… yeah	4
003	Ohhh… I get what you mean now…	11
001	And I am doing that (points to 002's support prototype)	8
002	Can you do it?	9
001	I will be able to….	11
001	(Picking up connected straws and platform)	1
002	I think you should put the straws in instead… (make more connected straws)	2
001	Oh yeah!	4
All	Building	-
002	Ok I think I have got it (straw support prototype) strong enough	12
003	Urghh I have done it again (end of tape sticking on tape itself)	11
002	What do you mean? (looks at 002)	8

All	Building	-
002	(softly) Oh I am so confused right now	11
003	Have you confused yourself?	9
002/003	(laughs)	-
001	Here you go (hands 002 connected straws)	12
002	(inspects connected straws) yeah but that doesn't look on the right side.	8
001	Have I done it wrong?	10
002	I don't know	12
001	No I have, its supposed to go in that way.	12
002	I noticed it but I dint say anything (Laughing)	11
001	Awwhhhh…	15
002	Its funny cause if it was in the cadets I would have been shouted at…	15
001	Interrupts	13
001	Like "oi! What are you doing!"	15
002	Like "why…!"	15
001	Alright there you go (hands 002 fixed connected straws)	12
002	This one's not gone in.	12
All	(laughs)	-
001	I also did this one wrong too.. (takes straw support prototype and fixes it)	12
001	This way it is not going to stand up is it	12
002	Wait just fold up some straws… (folds straws in a bunch)	2
001	Here you go (hands rectified prototype to 002)	12
002	(to 001) right so put that (straw prototype) around (aligned with the folded straws)	1
003	Aww no… don't start with another one now…	6
001	Right so if we do that there (shifts prototypes)	3
002	Wait… trust me… I meant don't but…	11
001/003	(laughs)	-

003	Trust me… I mean don't but trust me…	7
001	(takes up completed platform and connected straws)	-
001	Should I put these (connected straws and platform) in here so that it is like a longer bridge?	10
003	(to 002) can I do anything?	10
003	Instead of just cutting cello tape.	11
002	Yeah.. get some straws and bend them	1
003	Grab some straws and bend them…	1
002	Oooh actually can I get some big cello tape please	10
003	(sighs) alright then… (cuts cello tape for 002)	11
002	We have 5 more minutes!	12
001	Oh my god!	11
002	(Laughs)	-
001	I don't think this bridge is going to stand..	11
002	What bridge?	15
002/001	(Laughs)	-
003	What bridge? literally we only have a line of straws	15
002	I just really feel bad for the turtles (laughing)	15
001/003	Awwww =(	11
001	Oh no…. =(	11
003	Don't… because now I am feeling bad…	11
001	Why would you even state that….	7
003	I should have brought my reusable straw…	11
002	Maybe we could have used that	1
003	Just donate them	15
001	I need to get one… I don't have one but I will find one…	11
001	(to 003) is it like a metal one or is it like	11
003	It's a metal one yeah	11
001	Where do you get it? Is it like Amazon or something?	11
002	(laughs) Fine!!	15

001	When did you get it…..	11
003	I got it…..(starts to give answer)	11
002	Interrupts	13
002	Alright there we go (puts two completed bundled straw supports on table) put one on each side of the table	1
002	It has to be off the table isn't it?	8
002	(takes one bundled up straw support) that's off the table…	15
003	(Facepalms and laughs)	-
003	(to 002) Come here and help me	1
003	I am going to trim them (cut away uneven ends of bundled straws)	1
001	Right I am just going to remove (connecting straws and platform) and get them trimmed too.	3
003	(Finishes cutting straws) And voila	15
All	(Laughs)	-
003	Once again (points to 002) its all your fault	7
002	What!?	7
001	How is this… how is this… (tries to attach bundled straw support to platform)	10
002	Wait… I have missed one (straw)… how did I? (gasp)! (holds single straw against the bundle.	12
003	(to 002) unsupported… you cant hold it lol	15
002	I know…!!	12
001	Put some tape underneath it	1
002	(Takes tape and tapes straw on to bundle as proposed by 001)	4
001	Or get loads of them and wrap them…..	3
002	Interrupts (by cutting and reaching for completed connected straws in front of 001)	13
002	(takes out connected straws to get single straws) Sorry… I'm sorry… (to 001)	11
003	(Laughing)	-
001	Aww… Its alright	11

003	In tasks like this, time goes by really really quickly	11
002	They do…	11
002	Right I feel like I am really under a lot of pressure right now…	11
003	(Starts singing)	15
001	Why is that one so much longer than the rest (looking at straw support prototype)	10
002	I would be happy if I could have a longer piece (tape) than that	12
003	(shows 002 already cut long piece of tape)	12
001	Can I get the scissors please?	10
003	(Hands 001 scissors)	-
001	Thank you	11
002	Your singing isn't that very nice	7
003	No one is looking for your comment	7
001	(cuts straw, flying debris hits 002 in the arm)	-
002	Ooh oww	11
001	Right here we go… (places straw platform on both straw supports.)	1
002	Woah woah woah (rushes to get tape and stick on own straw support)	1
001	My side is ready	12
002	I know I am coming!!	11
003	If this manages to stay up I am going to be so impressed	11
	Platform is being stabled	-
001	Woahhh	11
002	Oh my god, we are done for…	11
	Bridge is built and does not fall	-
All	(exclaim in joy)	15
001	Right! No one breathe	15
002	I was so terrified I dint breathe	11
	(Bridge fell to the side as it was not taped)	-
All	(Jumps)	-

001	Quick (picks up the fallen bridge)	1
001	Tape it on (x3)	3
002	(to 003) go (x2) get yourself in, get your cello tape	1
001/002	(Finishes taping the platform to the supports)	-
001	Okay(x2)	12
001	I have never felt so stressed over straws (Tearing slightly)	15
All	(Laughing)	-
001	Like don't touch it	1
001	How much time do we have left?	10
003	We got 1 minute and 40 seconds left	12
002	Right we have got enough to reinforce so… (taske tape from 002 hand and tapes the top of the platform to the support)	1
001/003	(looks in shock, 001 covers face expecting something bad to happen)	-
003	(to 002) Oh what are you doing…	8
001	Ok yeah	11
002	(finishes taping structure) That's what I am doing, it is staying still.	12
001	Does it though?	8
003	It will	12
002	Right no one breathes for the next 2 minutes.	1
001	At least we made it though…	11
003	I know… I am quite proud that it managed to stay up..	11
002	Considering the fact though that 3 minutes ago we totally doubted whether this will stay up	11
003	I mean I don't know anything I was literally just cutting cello tape up.	15
All	(Laughing)	-
002	(false stiletto voice) What did you do today…	15
003	Cut cello tape up and built a straw bridge	15
All	(Laughs)	-
002	Without those supports, we are totally done for	15

003	(Laughs)	-
002	Because usually in cadets we normally don't have to built them because there are supports or something.	11
Researcher	Are you guys finished? (End of Task)	-
All	Yeap	-

Appendix D: Example of a fully coded Transcript of a team doing the GAUT virtually – Chapter 6 & 7 -(Numbers correspond to the associated category in Appendix A)

Who	Spoken text / Action	Behaviour Cat.
Researcher	First item is just a mug and you can start now	-
	Official start of Activity	-
004	To drink from	2
002	(interrupts) Bake with	13, 2
001	To hold things like pens	2
003	Eat out of	2
002	Eh….?	8
003	Oh you know… like a bowl?	3
004	That is a tiny bowl (laughs)	15
003	Leave me and my beautiful bowl alone please (showing mug on screen)	7
004	With that design? You don't even need to ask twice (laughs)	7
003	Well it was a gift from…..	11
001	(interrupts) Mugs can be a gift!	13,2
003	Oh yeah! Good one!	4
002	As a decoration	2
002	Nice	4
002	As an adjective	2
003	Trap things in….	2
002	(interrupts) Like insects or spiders	13, 3
002	Make a throw	2
003	Like a weapon	3
002	Yeah exactly	4
003	Got hit by a mug once, not fun that	11
004	No wonder you are so quick to respond	15
001	An ornament	2
002	As a basin for liquids	2

003	To wash your face?	8
002	Yeah	12
003	To make stuff in	2
001	(interrupts) like a mixing bowl	3
002	(Use as) Souvenir	2
002	Take camping	2
004	To pee in an emergency situation outdoors (gesturing)	**2**
004	Like you know…. In the wild without toilets	**3**
003	You sound experienced peeing in them	**15**
004	Well if in an emergency (shrugs)	**3**
001	Anything will do (laughs)	**15**
004	Coffee shops	2
003	To paint	2
001	Measure things in	2
004	Yeah good one	4
003	That's a good one	4
003	To draw around (stencil)?	2
004	Paperweight	**2**
002	To hold jewellery	2
003	Put a plant in there?	2
003	Like a plant pot	3
001	Nice	4
	End of activity	
Researcher	Okay so we're gonna move on to the next item	-

Appendix E: Example of a fully coded Transcript of a team's doing one iteration of the bridgebuilding task virtually - Chapter 7 - (Numbers correspond to the associated category in Appendix A)

Who	Spoken text / Action	Behavior Cat.
Researcher	and your 10 minutes start now	
	Official start of Activity	
002	Start with the road across the top.	2
001	The Road?	8
003	Does the road have to go straight?	10
002	I guess so.... because the weight can.....	12
002	We can only put from red point to red point cant't we.	10
003	Yeah.	12
002	So if the road didn't go straight, it wouldn't go.	12
001	We'd want the road to go flat across it.	12
003	Yeah.	**4**
001	I mean, I've never gone... unless it's (the road) never gonna rip up.	11
002	Yeah	4
002	So then we only have wood so either the wood goes like across (gesturing)	2
002	Or like two ways across or it goes like straight down on either side.	3
003	I mean we only got the red ones (preset-anchor points)	12
003	But there's no like point in the middle where the wood can go to is there?	10
001	I think there is.	12
002	I don't know. I can't see any	12
001	It depends, I feel like there is..... (other) points was there on the other bridges.	12
003	There's no yellow points on this though is there?	8
002	Yeah,	12

004	So surely we would have to go one through, one straight across than the other ones to go across.	2
003	Okay. Ah, okay. That's like any other bridge that	12
004	I think we just put road across and work out if it is joined together.	3
003	What's your thoughts about the bottom now?	10
003	Like put wood straight across the bottom?	2
002	I think we go like road (sections) across but in like, a couple joints	3
002	and then we use those couple of joints to go down.	3
003	So when you say go down, are we gonna attach it (road sections) to the bottom or like (use) another bit of wood?	8
001	Then it is wood on wood then isnt it.	8
002	Yeah. With wood at the bottom	12
001	Is that dark bit at the bottom, what.... like the floor?	10
002	No. I don't think so	12
003	I think it is water isnt it?	12
002	I think we could just attach it (road) to the wood.	3
002	Like a normal bridge, I guess... I dont know?	11
001	We'll make it like the Severn (bridge)	12
003	Would you have, like, wood across the bottom? '	10
002	Yeah	12
003	And then wood on the diagonal? Both ways.	12
001	Yeah.	4
002	We could do that.	4
003	And meet it in the middle at the bottom.	3
002	Yeah.	4
003	That would work... and then maybe one in the middle of going straight up as well?	3
002	Yeah. Yeah, I think that's well enough.	4
001	That's a fun way around	15

001	Yeah, I guess we'd want as many like those (triangles) as possible surely.	2
003	Yeah.	4
001	Well, I guess…. do you think you could probably have as loads of those?	10
004	But if they're not like, the right type, then that's probably a bit irrelevant.	12
001	But I don't know, never built a bridge before.	11
002	Yeah, I feel like two on each side and then one in the middle should be fine.	3
001	Then do we not want anything over the top of the bridge.	8
001	Because bridges have that as well dont they?	12
002	True	4
003	Yeah.	4
002	I was going to ask that about the demo (tutorial session). I don't know what the point of the.... (triangles)	11
001	Like that massive bridge going across from England, Wales. That's what a lot of it's got of (triangles)	12
003	It's got a lot of them (triangles) on the top isn't it?	12
002	What is the top stuff (triangles) do though?	8
003	It like supports the bridge from the top rather than from the bottom.	12
001	Mmhmm	4
002	So maybe we do the same on the top then?	2
003	What and have it equal both sides?	8
002	Yeah.	12
002	We don't have any joining points on the top though.	12
004	Yeah it would be midair	12
001	No….	6
002	(interrupts) We don't on the bottom too.	13, 12
003	We do because we can go red to red on the bottom.	6
003	That is a good idea	4

001	We've got red to red than on the middle bit as well.	12
001	We can go up and then you can join it together.	3
001	Cant you?	10
003	just like that like(gesturing)?	8
002	Yeah, let's just go like that (imitate gesture).	12
003	And then like that off the top and the bottom. zigzags?	3
002	Yeah, yeah.	4
004	Din't we have a budget as well though?	10
002	Nah, I think we just have like materials.	12
001	Yeah?	10
002	yeah.	12
001	All right.	12
002	Sounds good. That sounds like a good bridge.	4
001	We shall see	11
002	I will drive over it.	15
001	004. What's your verdict?	14
004	I think that sounds great. Yeah,	12
003	Do we need something going from red to red on the end?	10
004	What just from the red to....	8
004	I dont see what that will do	12
002	That was what I said but I don't know if it makes any difference	11
001	It is on the ground, isn't it?	8
003	Yeah.	12
001	If you want I guess it wouldn't do any damage.	11
002	That's how what I'm thinking is that if this bridge doesn't need to be aesthetically pleasing let's just chuck a bunch of wood around	11
003	that is heavy.	12
001	That's what I'm saying if we chuck those wood around and it's not like.....	12
002	(interrupts) So let's not do the side ones then because they're irrelevant	13, 2

003	If you chuck too much wood in there it would be too heavy and just collapse.	12
002	Good point	4
003	Exactly.	4
004	Yeah, no, I agree.	4
004	Needs to be the right amount isnt it .	3
002	Right so... (gesturing)	4
001	not sure how heavy the car is....	11
003	Is the joining points on the wood as well, or just the road	10
004	On the on the ends of the joints? I think...	12
003	So there are joining points on the road….	12
002	I mean you could attach it to the road?	2
004	Yeah, shall we build this as we go or not?	1
003	Am I allowed to draw (design on paper to show group)?	10
002	(laughs) They (researcher) are neglecting us...	15
004	Yeah.	4
004	What is that?	8
003	(Shows drawing on camera)	-
002	yeah i think that looks good	4
002	Wait what... I thought we were going to do the bottom like, like that (gesturing a previous design idea)	8
002	and then one like..... (gesturing some more)	3
003	or just one zigzag?	8
003	Oh hang on (redrawing new design)	1
002	Without it looks fine, though.	12
002	Do both (designs)?	1
003	(Shows new drawings)	-
002	Yeah. Okay. Nice.	4
003	I don't know.	11
002	We'll start at the top and with a plank of wood.	1

003	Yeah.	4
002	And then put in all the planks on the side.	3
003	Yeah, like, yeah, I didn't know if we can do that.	12
003	Yeah. If I could replicate this on a grid....	11
004	(interupts) We need bits that goes on the top as well....	13, 3
004	And those that comes down from that in the middle.	3
003	Well, like here? (pointing at a part of the design)	8
002	Do we?	10
004	I'm no engineer,	11
004	But what I do know is that provides no stability without starting to get in the middle of it	12
003	Yeah.	4
001	yeah	4
001	Otherwise, It's just a bit of wood, just chilling on top.	15
003	(Redrawing Diagrams)	-
004	Ah there you go boy,	5
002	Yeah nice.	5
002	What about the top though?	8
003	We need to do the top.	12
004	Well if one is coming down off.....	2
003	(interupt) Shall we zigzag the top as well?	13,3
002	Yeah. May as well.	4
003	Well enough….	4
003	That type of thing? (Shows new design)	8
003	It's not very symmetrical.	12
001	Yeah.	4
002	That look good	4
004	Yeap. cracking.	4
003	Okay. Can we do that now?	1
002	Yeah, I'm ready with that.	4

002	Yeah, I would be confident with that	4
003	let me draw it one more time just so that we can.....	1
004	I thought we are building as we go arent we?	8
003	I dont know are we allowed?	10
003	I dont know	12
001	Sure. Okay.	11
002	Yeah. nailed that	15
001	National bridge builders!	15
004	Cracking stuff.	15
002	Right, (researcher), I think we're ready.	12
	End of activity session	

Appendix F: Ethics forms (Project Ref: BT/03-2019/064)

Study 1 – (Chapter 4) – (BT/03-2019/064) –Participant Information Sheet

Edge Hill University

Title of Study: Factors affecting team dynamics, performance and creativity

You are being invited to take part in a research study. This information sheet explains why the research is being done and what it will involve. Please ask us if there is anything that is not clear or if you would like more information.

What is the purpose of the study?

This research project is investigating how various team diversity factors and providing team meeting feedback affects team dynamics, performance and creativity.

Who is conducting the research?

The principal researcher is Bryan Tang (email removed for GDPR) from the Psychology Department at Edge Hill University, Ormskirk. The study will form part of my PhD thesis. The research supervisor is Prof. Rod Nicolson (email removed for GDPR), Psychology Department, Edge Hill University.

Do I have to take part?

No. This is an entirely voluntary project and is an addition to the seminar curriculum for the module PSY1111. If you choose not to participate, it will not affect you in any way.

If you choose to take part, you will still be free to withdraw at any time up to four weeks after your participation, and without giving a reason and without incurring any consequence.

This may be done by contacting us using the details below with your assigned pseudonym which will be providing at the start of the questionnaire. This will allow us to identify your data to remove it.

What will I be asked to do?

You will first be given a Demographic form and a Big 5 Personality questionnaire to complete. After which you will be randomly assigned to teams and as a team complete 2 tasks within the time limit provided.

The entire session should take no longer than 2 hours. Your verbal behaviours exhibited during the team tasks will be coded using a behavioural analysis coding system.

Audio and video recordings of your team completing the assigned team tasks will be conducted. You have the option to opt out of having your team meetings recorded which you will indicate in the informed consent form.

What will I get for participating?

As the activities used for this study are also a part of your curriculum for the week 9/10 seminar for the module PSY1111, **NO** monetary compensation or SONA credits will be given for this study. However, by participating in this study, you will be able to obtain a summary and deeper understanding of how

team diversity and feedback can affect a team's dynamics, performance and creativity in addition to the curriculum taught in the seminars.

What are my rights as a participant?

This research is being conducted in accordance with the British Psychological Society's ethical guidelines, meaning you have a series of rights as a participant. All information you provide will be anonymous and treated with the strictest confidence. If you do decide to take part in this research, you have the right to withdraw your data at any time up to a period of 4 weeks after participating. This can be done without reason and will not be questioned. You can stop the study at any time and can do this without penalty and without providing a reason. You will not be identifiable by name at any point, as you will be referred to by a pseudonym in data files.

Use and Storage of Data:

The research data collected will be stored anonymously on password protected files for up to 10 years in line in line with GDPR (GDPR, 2018) and EHU data policy. Personal and identifiable data such as informed consent forms and student numbers will be disposed 4 weeks after the commencement of the study. The research data collected will only be used for dissemination of the study's findings (e.g., conferences, publication) and informing future research for the researcher's PhD. Although data for research may be stored for longer periods, it will not be stored for longer than necessary.

Ethical Review:

The ethics for the study has been reviewed and approved by the Psychology Department Research Ethics Committee (DREC). The Chair of the DREC is Dr. Andy Levy (email removed for GDPR)

Much research in psychology depends on participation by individuals like yourself. We are grateful for your help. If you are happy to participate, please read and sign the following consent form.

References:

General Data Protection Regulation (GDPR) – Final text neatly arranged. (2018). Retrieved from https://gdpr-info.eu/

Study 1 – (Chapter 4) – (BT/03-2019/064) –Participant Consent Form

Edge Hill University

Title of Study: Factors affecting team dynamics performance and creativity

This study is exploring how various factors might affect team dynamics, performance and creativity. If you are happy for us to collect and use your data for this research, please read and complete the consent form. Your data are anonymous and confidential, and you will not be identifiable at any time.

Please initial as indicated below: **Initial**

I confirm that I have read and understood the information sheet for the above study and understand what is expected of me _____

I understand that I am free to stop the study at any time and I am free to withdraw my data from the study up until 4 weeks after I have participated _____

I confirm that I have been given the opportunity to ask questions regarding the study and if asked, my questions were answered adequately and to my full satisfaction _____

I understand that my verbal behaviours will be recorded and codified, but I will not be identifiable in any written accounts or summaries of data. _____

I understand that I will be audio and video recorded during the session and the recording will be transcribed verbatim, but I will not be identifiable in any written accounts _____

Data Protection Act/GDPR

I understand that my personal data collected during my participation in this study will be destroyed after 4 weeks from the commencement of the study. Research data collected from me will be anonymized, securely stored and destroyed after 10 years in line with the data protection policies (GDPR, 2018) and EHU data policy.

I agree to Edge Hill University recording and processing my information and the collected information may be used for academic research purposes and presented in other academic forums (e.g., academic journals, at conferences, or in teaching). I understand that information will be used only for these purposes and my consent is conditional upon the University complying with its duties and obligations under Data Protection policies.

Your name (Print) _____

Your signature _____ **Date** _____

Please write down your allocated pseudonym here which you should use as a reference in instances of contacting the researcher to withdraw your data

_____

Study 1 – (Chapter 4) – (BT/03-2019/064) – Participant Debrief Sheet

Edge Hill University

Title of Study: Factors affecting team dynamics performance and creativity

Thank you for taking part in this study. Your participation will be very useful for helping us better understand how team diversity and providing feedback about team meetings can affect team dynamics, performance and creativity. After the data have been analysed, an email will be sent with a greater in-depth summary about your team dynamics and performance plus explanations on the various factors that might have affected it. If you require any further information or have any questions about this study, please do not hesitate to contact the lead researcher, using the details below.

Lead Researcher: Bryan Tang (email removed for GDPR)
Supervisors: Prof. Rod Nicolson (email removed for GDPR)
Prof. Simon Bolton (email removed for GDPR)

Please note that if you wish to withdraw your data from this study please email the lead researcher at the above email address with your assigned pseudonym and information about the date and time of your study within 4 weeks of taking part in this study. After 4 weeks your consent form will be destroyed and your performance data from the experiment will remain in an anonymised format and therefore cannot be destroyed thereafter. This will be stored for 10 years, in line with the data protection policies (GDPR) and EHU data policy.

If you need to contact somebody independent of the study, please contact Edge Hill University's Research Office on email removed for GDPR. If you experience any negative feelings after completing this study, please remember that there are a lot of services to help, should you need someone to talk to. Some of these are:

Mind

Telephone: 0845 766 0163

Website: mind.org.uk

The Samaritans

Telephone: 0845 790 9090

Website: samaritans.org

Please write down your allocated pseudonym here which you should use as a reference in instances of contacting the researcher to withdraw your data

_____

Study 2 – (Chapter 5) – (BT/03-2019/064) – Participant Information Sheet

Edge Hill University

Title of Study: Factors affecting team dynamics, performance and creativity

You are being invited to take part in a research study. This information sheet explains why the research is being done and what it will involve. Please ask us if there is anything that is not clear or if you would like more information.

What is the purpose of the study?

This research project is investigating how various team diversity factors and providing team meeting feedback affects team dynamics, performance and creativity.

Who is conducting the research?

The principal researcher is Bryan Tang (email removed for GDPR) from the Psychology Department at Edge Hill University, Ormskirk. The study will form part of my PhD thesis. The research supervisor is Prof. Rod Nicolson (email removed for GDPR), Psychology Department, Edge Hill University.

Do I have to take part?

No. This is entirely voluntary and if you choose not to participate, it will not affect you in any way. If you choose to take part, you will still be free to withdraw at any time up to four weeks after your participation, and without giving a reason and without incurring any consequence.

This may be done by contacting us using the details below with your assigned pseudonym which will be providing at the start of the questionnaire. This will allow us to identify your data to remove it.

What will I be asked to do?

The study should take no longer than 1 hour. This includes completing a demographics form, Big 5 Personality questionnaire, 3 team tasks to be completed within the time limit provided and a self-rating questionnaire at the end of the study.

If you agree to participate, your team will have the team meetings video recorded and you will agree for your data from the team's performance and completed questionnaires to be collected and used for this research study.

What will I get for participating?

You will be compensated according to the rate determined by the Psychology Department which is either 2 SONA credits or £8 for this study.

What are my rights as a participant?

This research is being conducted in accordance with the British Psychological Society's ethical guidelines, meaning you have a series of rights as a participant. All information you provide will be anonymous and treated with the strictest confidence. If you do decide to take part in this research, you have the right to withdraw your data at any time up to a period of 4 weeks after participating. This can be done without reason and will not be questioned. You can stop the study at any time and can do this without penalty and without providing a reason. You will not be identifiable by name at any point, as you will be referred to by a pseudonym in data files.

Data will be stored on password protected files for up to ten years in line in line with GDPR and EHU data policy. Data will be stored anonymously and will only be used for research purposes (e.g., conferences, publication).

Much research in psychology depends on participation by individuals like yourself. We are grateful for your help. If you are happy to participate, please read and sign the following consent form.

Study 2 – (Chapter 5) – (BT/03-2019/064) – Participant Consent Form

Edge Hill University

Participant Consent Form: Consent of verbal behaviours being coded

Title of Study: Factors affecting team dynamics performance and creativity

This study is exploring how various factors might affect team dynamics, performance and creativity. If you are happy for us to collect and use your data for this research, please read and complete the consent form. Your data are anonymous and confidential, and you will not be identifiable at any time.

Please initial as indicated below:	**Initial**
I confirm that I have read and understood the information sheet for the above study and understand what is expected of me	_____
I understand that I am free to stop the study at any time and I am free to withdraw my data from the study up until 4 weeks after I have participated	_____
I confirm that I have been given the opportunity to ask questions regarding the study and if asked, my questions were answered adequately and to my full satisfaction	_____
I understand that my verbal behaviours will be recorded and codified, but I will not be identifiable in any written accounts or summaries of data.	_____
I understand that I will be audio and video recorded during the session and the recording will be transcribed verbatim but I will not be identifiable in any transcripts of the data	_____

Data Protection Act/GDPR

I understand that my personal data collected during my participation in this study will be destroyed after 4 weeks from the commencement of the study. Research data collected from me will be anonymized, securely stored and destroyed after 10 years in line with the data protection policies (GDPR, 2018) and EHU data policy.

I agree to Edge Hill University recording and processing my information and the collected information may be used for academic research purposes and presented in other academic forums (e.g., academic journals, at conferences, or in teaching). I understand that information will be used only for these purposes and my consent is conditional upon the University complying with its duties and obligations under Data Protection policies.

Your name (Print) _____

Your signature _____ **Date** _____

Please write down your allocated pseudonym here which you should use as a reference in instances of contacting the researcher to withdraw your data

_____

Study 2 – (Chapter 5) – (BT/03-2019/064) – Participant Debrief Sheet

Edge Hill University

Title of Study: Factors affecting team dynamics performance and creativity

Thank you for taking part in this study! Previous research found providing feedback to affect overall team performance and creativity but not much investigated the effectiveness of providing feedback about team dynamics and how it interacts with other diversity factors such as personality, culture, SES and gender to affect team dynamics, performance and creativity. Your participation will help us better understand how team diversity and providing feedback about team meetings can affect team dynamics, performance and creativity. In the attached bibliography section, academic papers are available for you to read if you are interested to know more in detail.

After the data have been analysed, the general results and findings of the study will also be disseminated during a later lecture within the semester. You can email the lead researcher to request a greater in-depth summary about your team dynamics and performance plus explanations on the various factors that might have affected it. If you require any further information or have any questions about this study, please do not hesitate to contact the lead researcher, using the details below.

Lead Researcher: Bryan Tang (email removed for GDPR)

Supervisors: Prof. Rod Nicolson (email removed for GDPR)

Prof. Simon Bolton (email removed for GDPR)

Please note that if you wish to withdraw your data from this study please email the lead researcher at the above email address with your assigned pseudonym and information about the date and time of your study within 4 weeks of taking part in this study. After 4 weeks your consent form will be destroyed and your performance data from the experiment will remain in an anonymised format and therefore cannot be destroyed thereafter. This will be stored for 10 years, in line with the data protection policies (GDPR) and EHU data policy.

If you need to contact somebody independent of the study, please contact Edge Hill University's Research Office on email removed for GDPR. If you experience any negative feelings after completing this study, please remember that there are a lot of services to help, should you need someone to talk to. Some of these are:

Mind

Telephone: 0845 766 0163

Website: mind.org.uk

The Samaritans

Telephone: 0845 790 9090

Website: samaritans.org

Please write down your allocated pseudonym here which you should use as a reference in instances of contacting the researcher to withdraw your data

Study 3 – (Chapter 6) – (BT/03-2019/064) - Participant Information Sheet

Edge Hill University

Title of Study: Factors affecting team dynamics, performance and creativity

You are being invited to take part in a research study. This information sheet explains why the research is being done and what it will involve. Please ask us if there is anything that is not clear or if you would like more information.

What is the purpose of the study?

This research project is investigating how online collaborations interacts with team diversity factors to affect team dynamics, performance and creativity.

Who is conducting the research?

The principal researcher is Bryan Tang (email removed for GDPR) from the Psychology Department at Edge Hill University, Ormskirk. The study will form part of my PhD thesis. The research supervisor is Prof. Rod Nicolson (email removed for GDPR), Psychology Department, Edge Hill University.

Do I have to take part?

No. This is entirely voluntary and if you choose not to participate, it will not affect you in any way. If you choose to take part, you will still be free to withdraw at any time up to four weeks after your participation, and without giving a reason and without incurring any consequence.

This may be done by contacting us using the details below with your assigned pseudonym which will be providing at the start of the questionnaire. This will allow us to identify your data to remove it.

What will I be asked to do?

The study is conducted online on Zoom and should take no longer than 45 minutes. This includes completing a demographics form, Big 5 Personality questionnaire, a team task to be completed within the time limit provided and a self-rating questionnaire at the end of the study.

If you agree to participate, your team will have the team meetings video recorded and you will agree for your data from the team's performance and completed questionnaires to be collected and used for this research study.

What will I get for participating?

You will not be compensated immediately after the study however the top 3 performing teams for the team task will each be awarded £50 after the conclusion of the study.

What are my rights as a participant?

This research is being conducted in accordance with the British Psychological Society's ethical guidelines, meaning you have a series of rights as a participant. All information you provide will be anonymous and treated with the strictest confidence. If you do decide to take part in this research, you have the right to withdraw your data at any time up to a period of 4 weeks after participating. This can be done without reason and will not be questioned. You can stop the study at any time and can do this without penalty and without providing a reason. You will not be identifiable by name at any point, as you will be referred to by a pseudonym in data files.

Data will be stored on password protected files for up to ten years in line in line with GDPR and EHU data policy. Data will be stored anonymously and will only be used for research purposes (e.g., conferences, publication).

Much research in psychology depends on participation by individuals like yourself. We are grateful for your help. If you are happy to participate, please read and sign the following consent form.

Study 3 – (Chapter 6) – (BT/03-2019/064) - Participant Consent Form

Edge Hill University

Participant Consent Form: Consent of verbal behaviours being coded

Title of Study: Factors affecting team dynamics performance and creativity

This study is exploring how various factors might affect team dynamics, performance and creativity. If you are happy for us to collect and use your data for this research, please read and complete the consent form. Your data are anonymous and confidential, and you will not be identifiable at any time.

Please initial as indicated below:	**Initial**
I confirm that I have read and understood the information sheet for the above study and understand what is expected of me	_____
I understand that I am free to stop the study at any time and I am free to withdraw my data from the study up until 4 weeks after I have participated	_____
I confirm that I have been given the opportunity to ask questions regarding the study and if asked, my questions were answered adequately and to my full satisfaction	_____
I understand that my verbal behaviours will be recorded and codified, but I will not be identifiable in any written accounts or summaries of data.	_____
I understand that I will be audio and video recorded during the session and the recording will be transcribed verbatim but I will not be identifiable in any transcripts of the data	_____

Data Protection Act/GDPR

I understand that my personal data collected during my participation in this study will be destroyed after 4 weeks from the commencement of the study. Research data collected from me will be anonymized, securely stored and destroyed after 10 years in line with the data protection policies (GDPR, 2018) and EHU data policy.

I agree to Edge Hill University recording and processing my information and the collected information may be used for academic research purposes and presented in other academic forums (e.g., academic journals, at conferences, or in teaching). I understand that information will be used only for these purposes and my consent is conditional upon the University complying with its duties and obligations under Data Protection policies.

Your name (Print) _____

Your signature _____ **Date** _____

Please write down your allocated pseudonym here which you should use as a reference in instances of contacting the researcher to withdraw your data

_____

Study 3 – (Chapter 6) – (BT/03-2019/064) - Participant Debrief Sheet

Edge Hill University

Title of Study: Factors affecting team dynamics performance and creativity

Thank you for taking part in this study! The current COVID-19 pandemic has resulted in online collaborations being the new norm of interacting and communicating at the workplace. However, there is very little research investigating how online collaborations interacts with other team diversity factors such as personality, culture, SES and gender to affect team dynamics, performance and creativity. Your participation will help us better understand how online collaborations and team diversity factors can affect team dynamics, performance and creativity. In the attached bibliography section, academic papers are available for you to read if you are interested to know more in detail.

You can email the lead researcher to request a greater in-depth summary about your team dynamics and performance plus explanations on the various factors that might have affected it. If you require any further information or have any questions about this study, please do not hesitate to contact the lead researcher, using the details below.

Lead Researcher: Bryan Tang (email removed for GDPR)

Supervisors: Prof. Rod Nicolson (email removed for GDPR)

Prof. Simon Bolton (email removed for GDPR)

Please note that if you wish to withdraw your data from this study please email the lead researcher at the above email address with your assigned pseudonym and information about the date and time of your study within 4 weeks of taking part in this study. After 4 weeks your consent form will be destroyed and your performance data from the experiment will remain in an anonymised format and therefore cannot be destroyed thereafter. This will be stored for 10 years, in line with the data protection policies (GDPR) and EHU data policy.

If you need to contact somebody independent of the study, please contact Edge Hill University's Research Office on email removed for GDPR. If you experience any negative feelings after completing this study, please remember that there are a lot of services to help, should you need someone to talk to. Some of these are:

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Please write down your allocated pseudonym here which you should use as a reference in instances of contacting the researcher to withdraw your data

_____

Study 4 – (Chapter 7) – (BT/03-2019/064) - Participant Information Sheet

Edge Hill University

Title of Study: Factors affecting team dynamics, performance and creativity

You are being invited to take part in a research study. This information sheet explains why the research is being done and what it will involve. Please ask us if there is anything that is not clear or if you would like more information.

What is the purpose of the study?

This research project is investigating how various team diversity factors and providing team meeting feedback affects team dynamics, performance and creativity.

Who is conducting the research?

The principal researcher is Bryan Tang (email removed for GDPR) from the Psychology Department at Edge Hill University, Ormskirk. The study will form part of my PhD thesis. The research supervisor is Prof. Rod Nicolson (email removed for GDPR), Psychology Department, Edge Hill University and Prof. Simon Bolton email removed for GDPR, Edge Hill University.

Do I have to take part?

No. This is entirely voluntary and if you choose not to participate, it will not affect you in any way. If you choose to take part, you will still be free to withdraw at any time up to four weeks after your participation, and without giving a reason and without incurring any consequence.

This may be done by contacting us using the details below with your assigned pseudonym which will be providing at the start of the questionnaire. This will allow us to identify your data to remove it.

What will I be asked to do?

The study should take no longer than 2 hours. This includes completing a demographics form, Big 5 Personality questionnaire, 3 team tasks to be completed within the time limit provided and 2 self-rating questionnaires at the end of the study.

If you agree to participate, your team will have the team meetings video recorded and you will agree for your data from the team's performance and completed questionnaires to be collected and used for this research study.

What will I get for participating?

You will be compensated according to the rate determined by the Psychology Department which is £16 for this study.

What are my rights as a participant?

This research is being conducted in accordance with the British Psychological Society's ethical guidelines, meaning you have a series of rights as a participant. All information you provide will be anonymous and treated with the strictest confidence. If you do decide to take part in this research, you have the right to withdraw your data at any time up to a period of 4 weeks after participating. This can be done without reason and will not be questioned. You can stop the study at any time and can do this without penalty and without providing a reason. You will not be identifiable by name at any point, as you will be referred to by a pseudonym in data files.

Data will be stored on password protected files for up to ten years in line in line with GDPR and EHU data policy. Data will be stored anonymously and will only be used for research purposes (e.g., conferences, publication).

Much research in psychology depends on participation by individuals like yourself. We are grateful for your help. If you are happy to participate, please read and sign the following consent form.

Study 4 – (Chapter 7) – (BT/03-2019/064)Participant Consent Form

Edge Hill University

Participant Consent Form: Consent of verbal behaviours being coded

Title of Study: Factors affecting team dynamics performance and creativity

This study is exploring how various factors might affect team dynamics, performance and creativity. If you are happy for us to collect and use your data for this research, please read and complete the consent form. Your data are anonymous and confidential, and you will not be identifiable at any time.

Please initial as indicated below:	**Initial**
I confirm that I have read and understood the information sheet for the above study and understand what is expected of me	_____
I understand that I am free to stop the study at any time and I am free to withdraw my data from the study up until 4 weeks after I have participated	_____
I confirm that I have been given the opportunity to ask questions regarding the study and if asked, my questions were answered adequately and to my full satisfaction	_____
I understand that my verbal behaviours will be recorded and codified, but I will not be identifiable in any written accounts or summaries of data.	_____
I understand that I will be audio and video recorded during the session and the recording will be transcribed verbatim but I will not be identifiable in any transcripts of the data	_____

Data Protection Act/GDPR

I understand that my personal data collected during my participation in this study will be destroyed after 4 weeks from the commencement of the study. Research data collected from me will be anonymized, securely stored and destroyed after 10 years in line with the data protection policies (GDPR, 2018) and EHU data policy.

I agree to Edge Hill University recording and processing my information and the collected information may be used for academic research purposes and presented in other academic forums (e.g., academic journals, at conferences, or in teaching). I understand that information will be used only for these purposes and my consent is conditional upon the University complying with its duties and obligations under Data Protection policies.

Your name (Print) _____

Your signature _____ **Date** _____

Please write down your allocated pseudonym here which you should use as a reference in instances of contacting the researcher to withdraw your data

_____

Study 4 – (Chapter 7) – (BT/03-2019/064) - Participant Debrief Sheet

Edge Hill University

Title of Study: Factors affecting team dynamics performance and creativity

Thank you for taking part in this study! Previous research found providing feedback to affect overall team performance and creativity but not much investigated the effectiveness of providing feedback about team dynamics and how it interacts with other diversity factors such as personality, culture, SES and gender to affect team dynamics, performance and creativity. Your participation will help us better understand how team diversity and providing feedback about team meetings can affect team dynamics, performance and creativity. In the attached bibliography section, academic papers are available for you to read if you are interested to know more in detail.

After the data have been analysed, the general results and findings of the study will also be disseminated during a later lecture within the semester. You can email the lead researcher to request a greater in-depth summary about your team dynamics and performance plus explanations on the various factors that might have affected it. If you require any further information or have any questions about this study, please do not hesitate to contact the lead researcher, using the details below.

Lead Researcher: Bryan Tang (email removed for GDPR)

Supervisors: Prof. Rod Nicolson (email removed for GDPR)

Prof. Simon Bolton (email removed for GDPR)

Please note that if you wish to withdraw your data from this study please email the lead researcher at the above email address with your assigned pseudonym and information about the date and time of your study within 4 weeks of taking part in this study. After 4 weeks your consent form will be destroyed and your performance data from the experiment will remain in an anonymised format and therefore cannot be destroyed thereafter. This will be stored for 10 years, in line with the data protection policies (GDPR) and EHU data policy.

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Website: mind.org.uk

The Samaritans

Telephone: 0845 790 9090

Website: samaritans.org

Please write down your allocated pseudonym here which you should use as a reference in instances of contacting the researcher to withdraw your data

_____

Study 4 – (Chapter 7) – (BT/03-2019/064) – Ethics approval letter from Edge Hill University School Research Ethics Committee

RE: SREC approval for minor amendments (rerun of previously approved study)

Lars McNaughton <[redacted]>
Fri 28/01/2022 10:19
To: BRYAN WEN XIAO TANG <[redacted]>
Cc: Rod Nicolson <[redacted]>

Hi Bryan

I have no issues with the extension/re-run of the previously approved (DREC) study!

Best Wishes
Lars

From: BRYAN WEN XIAO TANG <[redacted]>
Sent: 23 January 2022 12:53
To: Lars McNaughton <[redacted]>
Cc: Rod Nicolson <[redacted]>
Subject: SREC approval for minor amendments (rerun of previously approved study)

Hi Lars,

I hope you are doing well.

Could you please review the attached tracked changes amendment proposing a rerun of a previous SREC approved study for my PhD with no change to the methodology and tasks.

Please let me know if you have any questions or need additional information.

With regards
Bryan Tang

PhD Researcher

Department of Psychology

Edge Hill University

Study 4 – (Chapter 7) – (BT/03-2019/064) – Ethics approval letter from Cardiff University School Research Ethics Committee

Ethics Feedback - EC.22.02.08.65.21

psychethics <[redacted]>
Fri 11/02/2022 08:55
To: Bryan Tang <[redacted]>

Dear Bryan,

The Ethics Committee has received the copy of your project proposal: Factors affecting team dynamics, performance, and creativity.

The Committee has noted that the proposal has already received ethical approval from Edge Hill University on 9th February 2022 (BT/03-2019/064).

The proposal has been registered on our database and has been given the following reference number: **EC.22.02.08.65.21.**

Conditions of this decision
The favourable opinion is subject to the following conditions being met:

- You must retain a copy of this decision letter with your Research records.
- Please note that if any changes are made to the above project then you must notify the Ethics Committee.
- Please use the EC reference number on all future correspondence.
- The Committee must be informed of any unexpected ethical issues or unexpected adverse events that arise during the research project.
- The Committee must be informed when your research project has ended. This notification should be made to [redacted] within three months of research project completion.

The Committee reminds you that it is your responsibility to conduct your research project to the highest ethical standards and to keep all ethical issues arising from your research project under regular review.

You are expected to comply with Cardiff University's policies, procedures and guidance at all times, including, but not limited to, its Policy on the Ethical Conduct of Research involving Human Participants, Human Material or Human Data and our Research Integrity and Governance Code of Practice.

Kind regards,
Deborah

School of Psychology Research Ethics Committee
https://cf.sharepoint.com/teams/InsidePsych/Ethics/

Cardiff University
Tower Building
70 Park Place
Cardiff
CF10 3AT

[redacted]

Prifysgol Caerdydd
Adeilad y Tŵr
70 Plas y Parc
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CF10 3AT

[redacted]