



DISSERTATION | DOCTORAL THESIS

Titel | Title

Supporting teams that collaborate through video conferences
with the help of Computer Science

verfasst von | submitted by

Mag.rer.soc.oec. Thomas Spielhofer

angestrebter akademischer Grad | in partial fulfilment of the requirements for the degree of
Doktor der Wirtschaftswissenschaften (Dr.rer.oec.)

Wien | Vienna, 2025

Studienkennzahl lt. Studienblatt | Degree
programme code as it appears on the
student record sheet:

UA 796 305 175

Dissertationsgebiet lt. Studienblatt | Field of
study as it appears on the student record
sheet:

Wirtschaftsinformatik

Betreut von | Supervisor:

Univ.-Prof. Dipl.-Ing. Dr. Renate Motschnig
Assoz. Prof. Dipl.-Ing. Dr.techn. Sebastian
Tschatschek BSc

Acknowledgments

The author wishes to extend his heartfelt gratitude to all the people without whom this work would not have been possible, and who contributed to making this learning journey as personally rewarding and insightful as it was. Most of all, to my supervisor Univ.Prof. Dr. Renate Motschnig, for her unwavering and most helpful support. Furthermore to Dr. David Haselberger for the highly inspiring research cooperation we had, Dipl.Wirt. Math. Tatjana Ruthardt for her most valuable feedback coming from a different perspective, the University of Vienna for providing me the chance and environment to conduct this thesis, and to Dipl.Ing. Martin Kahr and Michael Hartinger for helping to kick off the initial software prototype used in this thesis.

Table of Contents

1	Abstract	1
2	Zusammenfassung	2
3	Introduction	3
3.1	Motivation and Context	3
3.2	State of the art	7
3.2.1	ICT based analysis and support for online communication	7
3.2.2	Communication patterns and team performance	7
3.2.3	Social network analysis	8
3.2.4	Data visualization	9
3.2.5	Team coaching	10
3.3	Research gap	11
3.4	Research objectives	11
4	Reference framework Digitally Supported Coaching	14
5	Methods	15
5.1	Preamble	15
5.2	Case Study Design	15
5.3	Mixed Methods	17
5.3.1	On the origin and purpose of mixed methods	17
5.3.2	Applying mixed methods to analyze group interactions	18
5.3.3	Mixed methods used in this doctoral thesis	18
5.4	Quantitative Analysis	20
5.4.1	Data collection	20
5.4.2	Social network analysis	21
5.4.3	Data analysis	22
5.4.4	Data visualization	22
5.5	Qualitative Methods	22
5.6	Design science approach	23
5.6.1	Why using design science research?	23
5.6.2	Applying design science research to visualization artifacts	23
6	Synopses of Publications	25
6.1	Paper 1: Developing Teams by Visualizing Their Communication Structures in Online Meetings	25

6.2	Paper 2: Digitally supported coaching and its application to developing self-organizing teams	27
6.3	Paper 3: Using digitally supported communication analysis to facilitate constructive discourse in educational courses	29
6.4	Paper 4: Unveiling Communication Patterns: Helpful Visualizations of Communication in Online Video Conferences	32
6.5	Paper 5: Framing self-organized online team collaboration in a higher education course on Informatics and Society	34
7	Discussion	37
7.1	Learning from communication patterns with the help of ICT.....	37
7.2	Learning about roles and leadership	39
7.3	Supporting self-organized online learning	41
7.4	Impact and effects.....	41
7.5	Limitations	43
8	Conclusions.....	43
8.1	What we can learn from this research	43
8.2	Outlook.....	44
8.3	Personal conclusions	45
9	Bibliography	46
10	Complete Bibliography in Alphabetical Order	50
11	Appendix A: Publications	57
11.1	Paper 1: Developing Teams by Visualizing Their Communication Structures in Online Meetings	57
11.2	Paper 2: Digitally supported coaching and its application to developing self-organizing teams	75
11.3	Paper 3: Using digitally supported communication analysis to facilitate constructive discourse in educational Courses	87
11.4	Paper 4: Unveiling Communication Patterns: Helpful Visualizations of Communication in Online Video Conferences	98
11.5	Paper 5: Framing self-organized online team collaboration in a higher education course on Informatics and Society	105

1 Abstract

This research examines how online collaboration in video conferences can be supported with the help of Information and Communications Technology (ICT). It evaluates how teamwork can be improved by reflecting communication patterns. This follows the underlying assumption, coming from communication theory, that patterns are key in understanding communication. To that avail, a framework for computer-generated analysis and visualization of communication was created. Structural information regarding communication in video conferences was visualized and then discussed with the teams in so-called digitally supported coaching (DSC) sessions. The DSC framework also features the possibility to infer a social network based on the interaction taking place in video conferences. This was used in mixed methods approaches as a second perspective on group interaction compared to the subjective view of the participants. The subjective views were gathered through the answers to questionnaires, which were then processed by means of qualitative content analysis. Several multiple case studies situated in different contexts, using different research designs, evaluated how this approach contributed to the teams' reflection of collaboration. The results show that meaningful insights both on structural and individual level of team interaction were found. These findings range from better understanding of leadership in a team through general insights on how collaboration can be improved to adapting individual behaviour to better serve the discussion flow. This shows the potential of analyzing and visualizing metadata of video conferences to make patterns visible - patterns, that are highly relevant for team collaboration but might otherwise go unnoticed. The convergent findings of the overall twelve cases examined were used to postulate some criteria on how ICT tools and processes that use structural metadata of video conferences can be created to support teams in reflecting and learning from their online collaboration. Furthermore, this thesis examined what kind of frame can be helpful for online learning settings for large student groups. Conducting a case study led to insights how gamification can be used to that end. The students' feedback aggregated through qualitative content analysis showed promising feedback to this approach. The answers to the scaling questions how well it supported learning on a content and on social level both resulted in a median of 8 (1 being worst and 10 being best). Based on this qualitative content analysis, some guiding criteria was deducted on how to successfully implement an online environment, that supports the idea of self-organized learning. In this, it emphasises to carefully set the learning frame in terms of organizing communication within teams and in between teams. The gamification adapted for this purpose and used in this study can serve as a basis to that end.

2 Zusammenfassung

Diese Forschungsarbeit widmet sich der Frage, wie die Online-Zusammenarbeit in Videokonferenzen mit Hilfe von Information and Communications Technology (ICT) unterstützt werden kann. Konkret wird untersucht, wie die Teamarbeit durch die Reflexion von Kommunikationsmustern verbessert werden kann. Dies folgt der aus der Kommunikationswissenschaft stammenden Grundannahme, dass Muster der Schlüssel zum Verständnis von Kommunikation sind. Zu diesem Zweck wurde ein Framework für die computergenerierte Analyse und Visualisierung von Kommunikation geschaffen. Strukturelle Informationen über die Kommunikation in Videokonferenzen wurden visualisiert und anschließend mit den Teams in so genannten digital supported coaching (DSC) Sitzungen reflektiert. Das DSC-Framework bietet auch die Möglichkeit, aus der Interaktion in den Videokonferenzen auf ein soziales Netzwerk zu schließen. Dies wurde in Mixed-Methods-Ansätzen als zweite Perspektive auf die Gruppeninteraktion im Vergleich zur subjektiven Sicht der Teilnehmer genutzt. Die subjektiven Ansichten wurden durch die Beantwortung von Fragebögen erhoben, die dann mittels qualitativer Inhaltsanalyse verarbeitet wurden. In mehreren Fallstudien in verschiedenen Kontexten und mit unterschiedlichen Forschungsdesigns wurde untersucht, wie dieser Ansatz zur Reflexion der Zusammenarbeit in den Teams beiträgt. Die Ergebnisse zeigen, dass sowohl auf der strukturellen als auch auf der individuellen Ebene der Teaminteraktion aussagekräftige Erkenntnisse gewonnen wurden. Diese Erkenntnisse reichen von einem besseren Verständnis der Führung in einem Team über allgemeine Erkenntnisse darüber, wie die Zusammenarbeit verbessert werden kann, bis hin zur Anpassung des individuellen Verhaltens, um die Diskussion besser in Gang zu bringen. Darüber hinaus wurde in dieser Arbeit untersucht, welche Art von Rahmen für Online-Lernumgebungen für große Student:innengruppen hilfreich sein kann. Die Durchführung einer Fallstudie führte zu Erkenntnissen, wie Gamification zu diesem Zweck eingesetzt werden kann. Das durch die qualitative Inhaltsanalyse aggregierte Feedback der Studierenden zeigte ein vielversprechendes Feedback auf diesen Ansatz. Die Antworten auf die Skalenfragen, wie gut es das Lernen auf inhaltlicher und sozialer Ebene unterstützte, ergaben beide einen Median von 8 (mit 1 als der schlechtesten und 10 der besten Bewertung). Auf der Grundlage dieser qualitativen Inhaltsanalyse wurden Kriterien abgeleitet, wie eine Online-Umgebung, welche die Idee des selbstorganisierten Lernens unterstützt, erfolgreich umgesetzt werden kann. Ein wesentlicher Punkt dabei ist, den Lernrahmen sorgfältig festzulegen, um die Kommunikation innerhalb der Teams und zwischen den Teams zu organisieren. Der für diesen Zweck angepasste Gamification-Ansatz, der in dieser Studie verwendet wurde, kann als Grundlage für diesen Zweck dienen.

3 Introduction

3.1 Motivation and Context

The research presented in this thesis aims to contribute to improvements in online collaboration conducted via video conferences. It seeks to assist teams across various contexts in reflecting on and improving their online collaboration processes supported by Information and Communications Technology (ICT):

- In business contexts, by helping teams to identify and reflect more and less helpful patterns in their communication,
- for self-organized teams in non-profit organizations, to help discern and improve their (often informal) structures in leadership and self-moderation,
- in the field of education, by investigating how lecturers can create online learning environments that foster both learning and effective and inclusive social interaction among students.

Supporting teams that collaborate online has become increasingly important over the past years. Communicating online through video conferences has become a prevalent mean in education, business and private life - a process that had been strongly accelerated by the COVID-19 pandemic. The Internet and various communication tools based on it have brought together many people that would have otherwise been more disconnected. But the switch from personal contact to getting in touch with one another through the displays of computers, mobile phones and tablets, came with downsides for the people involved. This includes detrimental effects on productivity as well as on the social fabric of the company and their employees, even stretching to their private lives.

Research prior to the Covid-19 pandemic has already shown that the experience of working in virtual offices can be socially isolating (Cooper & Kurland, 2002; Mulki & Jaramillo, 2011). This may come as no surprise. However, the social impact of online collaboration goes beyond the boundaries of the organizations the respective people work in. A comparison between working in home-office and co-working spaces in Germany has shown that “advantages of the coworking space were found to be very pronounced with regard to productivity, the ability to concentrate, and self-organization.” (Robelski et al., 2019). Among other things, this study shows, that, paradoxically, self-organization seems easier when amid colleagues, than when being at home. Another study conducted in Germany showed that extensive online collaboration at work also had an impact on the private life of the employees. Their “relationship satisfaction turned out to have decreased, almost irrespective of whether respondents experienced changes in their employment situation during the COVID- 19 crisis or not” (Schmid et al., 2021). A study conducted in Luxembourg formed the hypothesis that the use of digital tools “appears to generate too much information flow to deal with and

teleworkers may suffer from information overload that increases their stress and reduces their job satisfaction and job productivity.” (Martin et al., 2022).

Virtual communication can become more disrespectful compared to people working on site together. A phenomenon that has been termed “cyber incivility”. A study in Singapore has defined cyber incivility as “communicative behavior exhibited in computer-mediated interactions that violate workplace norms of mutual respect.” (Lim & Teo, 2009). This study also found that such behavior has reciprocal effects as it “engenders different negative attitudes and behaviors from the victims.” Effects, that can have immediate impact on the health of the victims of cyber incivility, such as increased blood pressure (Taylor et al., 2005).

While the conclusions of these studies vary, they clearly indicate that there is room for improvement in online collaboration, both in terms of effectiveness and social interaction. But for all its apparent shortcomings on the social level, online communication has one advantage compared to on-site communication: it produces data. More specifically, it provides precise measurement of what could be framed as communication metadata. Metadata in this understanding comprises the interactions between the people involved, the length of speech and the number of contributions each participants had, but not the content of what is being said. This leads to a core research proposition of this work: ICT can provide support for online collaboration by discerning and visualizing patterns in communication metadata. These visualizations can serve as a basis for reflection and improvement for teams as a part of a coaching process specifically tailored for this purpose. To that avail, the author has developed and evaluated a framework as part of this thesis: the Digitally Supported Coaching (DSC). The DSC aims to provide social as well as business benefits for the teams using it. It is meant to contribute a piece of remedy to the current shortcomings of online collaboration that have been noted by the research mentioned above.

This core research proposition is founded on one side by the high number of methods and tools to discern patterns in data structures that data science has to offer. On the other side it is founded in communication theory, for discerning patterns in communication can be considered as key to understanding and improving collaboration. Watzlawick, Bavelas and Jackson state in their communication theory that “the search for pattern is the basis for all scientific investigation. Where there is pattern there is significance - this epistemological maxim also holds for the study of human interaction” (Watzlawick et al., 2011). Their communication theory is rooted in several scientific fields: Besides previous theories and research in psychology, it uses cybernetics to define a model of interaction between human beings. This aspect of the communication theory could be referred to as a structural view of communication: Communication is seen as a system of feedback loops between subsystems that has its inherent rules. Watzlawick’s, Bavelas’ and Jackson’s use the game of chess as a simile for interaction patterns. An observer, who does not know the game of chess could deduct the rules being followed by the players. All the observer would have to do is to watch a sufficiently long series of games being played for all inherent rules to become apparent. In this theory, communication, when seen as interaction between players and the inherent lawfulness of their interaction, is defined as a stochastic process. “Stochastic process refers to the lawfulness inherent of symbols or events”, for instance, “the

patterns of tonal and orchestral elements by a composer”. (Watzlawick et al., 2011). A stochastic process implies that in each context, some events are more likely to happen than others. In Mozart’s piano sonatas, an adagio is likely to be followed by a faster format. Had he an Adagio written to be followed by an Andante, a listener familiar with Mozart would be surprised, even if he or she had never studied the formal structure of Mozart’s compositions. The participants, however, are typically oblivious to their own communication patterns, as the authors argue: “we are particularly unaware of the rules being followed in successful, and broken in disturbed, communication” (Watzlawick et al., 2011).

This understanding of communication focusing on the interaction between people shows remarkably propinquity to the definition of social network analysis (SNA): “The objective of social network analysis is the description and analysis of relationships between different actors” (Huber & Froehlich, 2020). An actor in SNA definition could be a person or a social subsystem, depending on the scope and aim of the analysis. Understanding relationships and patterns in social systems is at the core of SNA. The interest in SNA “can be attributed to the appealing focus of social network analysis on relationships among social entities, and on the patterns and implications of these relationships.” (Wasserman & Faust, 1994).

These similarities between SNA and Watzlawick’s, Bavelas’ and Jackson’s communication theory provides a good basis to operationalize and measure relevant aspects in human communication, as will unfold in this thesis. The structural view on communication serves as a well-suited basis for the DSC. Firstly, because discerning patterns is considered key in understanding and improving communication. Secondly, patterns, as defined here, can be operationalized and measured by means of the current video conferencing solutions with the suitable add-ons being developed. A pattern in a series of video conferences could for instance be the dominant role of a person within a group. Something that can become apparent when viewing the centralities of the group members provided by the SNA. The DSC also aims to shed light on other types of patterns, such as the communication sequences typically occurring before good or bad decisions are being made. Does a team fare better, when only few team members speak, and one person has the proverbial last word? Or do good decisions arise from a sequence of dense, short interactions, that slowly evolves into a common sense of the group? Aspects in communication that are not easily discernible in SNA-like visualizations such as sociograms. Therefore, the communication report featured by the DSC offers different types of visualizations. They all have in common that they are solely based on the communication metadata, not heeding the content of what is being spoken in a video conference. This has the added benefit that the DSC or any similar framework is per se language independent, which widens its applicability.

Furthermore, all visualizations are based on data measured by an algorithm and not the subjective perspectives of human observers. In that respect, the communication report represents a view on communication that is complementary to traditional coaching methods that rely on the internal views of the team members or the outside view of a coach.

A key part of the work leading to this thesis was the development of the coaching process combined with a matching software tool that evolved into the DSC. The DSC, combined with existing methods, was used as a framework for answering the research questions.

Summarizing, the key motivation for this research is to leverage the potential of combining communication theory with data science to help teams to improve their online collaboration. The approach is based on a humanistic understanding of applying ICT, as expressed in the Vienna Manifesto of Digital Humanism: “Decisions with consequences that have the potential to affect individual or collective human rights must continue to be made by humans.” (<https://caiml.org/dighum/dighum-manifesto/>). In the spirit of that ethical principle, the approach aims to support humans in making better decisions on how to improve their collaboration based on the available data. It intends to do so by broadening the understanding of their collaboration rather than by pre-selecting decision options, as any pre-selection would limit the decision-making horizon instead of increasing the understanding that leads to the decision.

Key parts of this thesis cover the evaluation of the DSC approach in different contexts and by means of different scientific methods. Further research done as part of this thesis evaluates how video conferences can be framed in a way to provide a helpful learning environment.

3.2 State of the art

3.2.1 ICT based analysis and support for online communication

Previous research addresses in how far visualizing communication in video conferences can help improve online team collaboration. (Samrose et al., 2018) evaluated ways of analyzing and visualizing online video communication. The tool evaluated there featured a communication analysis including emotional expressions and turn taking from the individual perspectives of each participant.

So called “temporal patterns” were analyzed in global virtual project teams (GVPTs) by a research team (Massey, 2003). Temporal patterns were defined as the flow of interactions over time that influence communicative, decisional, and interpersonal behaviors in teams. The aim of the study was to explore “the nature of team interaction and the role of temporal coordination in asynchronously communicating GVPTs” (Massey, 2003). Temporal patterns could be seen as similar in some respects to what Watzlawick’s, Bavelas’ and Jackson’s describe as communication patterns.

More recent research has measured “the intensity of various aspects of users’ communication activity in periodic manner” (Muszyńska & Swacha, 2021). In this research, factors like discrepancies in project activities and variations in user activity levels were illustrated to identify different types of team communication challenges.

Commercial applications exist to coach individual participants on their behavior in online meetings. The Revenue Accelerator by Zoom¹ analyses specific interactions, for instance the frequency in which customers answer questions or how concise the dialogues between a sales agent and a customer are. It is meant to provide sales staff with tools to optimize their sales meetings. The Speaker Coach by Microsoft² provides feedback to a participant based on the spoken content. A recommendation by this tool might for instance be to use a more inclusive language. This solution uses voice recognition and large language models to process audio tracks of speakers and derive recommendations from it.

3.2.2 Communication patterns and team performance

As previous research shows, communication patterns as defined here, can be relevant for team performance. As early as 1950, Bavelas explored communication patterns within task-oriented groups (Bavelas, 1950). Preliminary conclusions from a series of

¹ https://www.zoom.com/en/products/conversation-intelligence/?_ics=1715786948776&irclickid=~4-b70290YRZ340UJJQXNEFLPHyzrld8bhi~-7ZYWPOKIFAqne&_ga=2.150623414.1271705200.1715786544-650308465.1715786543

² <https://support.microsoft.com/en-us/office/preview-speaker-coach-in-microsoft-teams-meetings-30f50d15-5f62-4e09-b3bf-cadeb806386a>

experiments suggested that both group performance and social dynamics could correlate with the information flow within the group. Social dynamics included factors such as leadership roles and group members' satisfaction. Bavelas' work is widely regarded as the foundation for subsequent experiments linking communication patterns to group performance (Sodeur, 2019).

More recently, the relevance of communication patterns for team performance has been investigated in a joint research project by MIT, Carnegie Mellon and other universities. The aim of this study was to investigate whether there is evidence for collective intelligence (Woolley et al., 2010). The study introduced an intelligence test for groups, measuring the performance in solving work-related tasks. The study measured the individual intelligence as well as many aspects of the team communication of randomly assembled teams in several hundred experiments. The research found evidence supporting the thesis that a general collective intelligence factor exists in groups. The study found two factors with significant correlation to collective intelligence. Firstly, collective intelligence was higher when females were part of the group. This was attributed to higher levels of empathic behaviour by female team members. The second insight was that collective intelligence "negatively correlated with the variance in the number of speaking turns by group members." (Woolley et al., 2010). Turn taking refers to the number of times a person spoke within a conversation. The more balanced turn taking was in a team, the higher the collective intelligence was bound to be. Similar results were found by the company Google in their Aristotle project, on the quest to find out what marks the company's best performing teams (Duhigg, 2016).

Alex Pentland conducted extensive research on human interaction and its impact on the performance of teams and organizations. By using ICT to gather detailed communication data over large periods of time, he arrived at the following conclusion: 'In studies of more than two dozen organizations, I have found that interaction patterns typically account for almost half of the performance variation between high- and low-performing groups.'" (Pentland, 2014)

3.2.3 Social network analysis

In this thesis, social network analysis serves as one mean (among others) to discern patterns inherent to online team communication. Traditional strengths of SNA lie in measuring and visualizing positions of team members and the relationships between them. Team positions and relationships and how they change with context and over time reflect some aspects of communication patterns as defined here: SNA can be derived solely from communication metadata, revealing patterns such as recurring balances in the centralities of two team members. SNA has a several decades long tradition both in scientific research as well as in practical application, including team coaching. It can therefore serve as a meaningful resource for the DSC.

SNA has been applied to social systems of different scale:

1. Sociological analysis of groups: Starting with J.L Moreno in the mid-20th century, the field of sociometry has opened a then new scientific field. Moreno initially

described sociometry as “Sociology of microdynamic processes” (Moreno, 1996). Moreno’s original intent was to use it to analyze small social systems like school classes or work teams, as his early work reflects (Moreno, 1941).

2. Using SNA for larger organizations or informal networks: Both scientific research as well as commercial applications exist on applying SNA to larger networks. As far as can be assessed from the outside, Google and Facebook use SNA (among other things like personal data of the user) for their ranking algorithms (Pariser, 2011).

As this research focuses on the analysis of team communication, mostly the first point is of relevance: Using SNA to analyze groups. When analysing groups, it is useful to differentiate between analyzing the whole structure of a social network vs. analyzing individual positions within a group (Huber & Froehlich, 2020). The former concerns aspects such as the reciprocity of relationship patterns, while the latter focuses on how central or prestigious a person’s position is within a group. It has been argued that “in practice, the analysis of networks is most productive when a sociogram or individual sociogram is used to analyze the particular structural situation of a person in the group and its possible dynamics”³ (Stadler, 2013).

To assess a position of a person in a group, various centrality metrics have been established. The degree centrality measures the number of relationships to other group members (sometimes weighed by the intensity of the respective relationship), while other measures like in-between- or closeness-centrality focus on specific aspects of the position within a group. A broad scientific discourse among mathematicians, sociologists, and psychologists explores which metrics are most appropriate for different social contexts (Bonacich & Lloyd, 2001; Landherr et al., 2010; Majeed et al., 2020; Opsahl et al., 2010; Rousseau & Zhang, 2008).

3.2.4 Data visualization

Human communication is multi-layered and complex. Even when just focusing on metadata of communication, there are infinite ways of visually representing the conversation of an online team meeting. Fortunately, extensive work exists that provide guidance on how to adequately represent data in graphs and illustrations. General guidelines have been provided (Kirk, 2019; Midway, 2020; Tufte & Graves-Morris, 2014) as well as particular criteria for visualizing data of social systems (Healy & Moody, 2014; Kennedy & Hill, 2018).

A key question in this research is to what extent visualizations should reflect the complexity of the communication they represent. The paradox lies in preserving enough information to accurately reflect a meeting conversation while ensuring that recipients are not overwhelmed by excessive detail - allowing them to see the bigger picture without getting lost in the details. (Kirk, 2019) suggests that “to overcome chart types that are unfamiliar a viewer must be provided with the means to learn how to perceive and interpret a chart.” Following that guidance, we need not only consider the form in

³ Translation from German by the author of this thesis

which communication metadata is represented, but we also can and should influence the frame and the manner it is conveyed to the recipients. It is therefore relevant to understand the previous knowledge of the participants of a DSC: How familiar they are with sociogram-like visualizations, or how well they are used to discern commonalities and differences in visualizations of different meetings, to name two examples. That way, the explanations provided to the team members can be adjusted accordingly, thus increasing the chance meaningful insights can be gained.

The empirical findings regarding the eligibility of visualization types in the DSC as well as criteria for creating communication reports are elaborated in paper 4.

3.2.5 Team coaching

To recognize and change patterns is not only relevant from an epistemological perspective. To understand and work with them is also considered to be key in some coaching and therapeutical approaches. Symptoms can be seen as an “over-stability of patterns inadequate to solve new tasks” (Kriz, 2013). The actualizing tendency in the person-centered-approach as well as the phase transition in systems theory both deal with the delicate question on how a transition to new patterns can be accomplished. Old patterns are appreciated as having been helpful at some point in time but now deserve an update. The aim is to find patterns that are more adequate to the today’s reality of a person or a team.

Various approaches for team coaching exist. For the DSC and this thesis, those approaches are of particular interest, that make use of a structural view on communication. There is one branch of coaching, referred to as constructivist-systemic coaching, that is based on the communication theory by Watzlawick, Bavelas and Jackson (De Shazer, 1988, 1991; Tomm, 1988, 2014). A particular focus in DeShazer’s work is to look for “differences that make a difference”. A term that was used by Gregory Bateson as definition for information (Bateson, 2000). The aim in this approach to team coaching is to “facilitate movement toward desired team positions as defined by the team” (Pavlović, 2021).

In a constructivist-systemic understanding, it is the perspective of the coachee (or the coachees in a multi-person setting) on a subject that matters. The coach guides the coachees towards finding solutions for themselves through questions, hypotheses and other interventions, all coming from an inner stance of benevolence and open-minded supportiveness.

Clearly there are further relevant aspects in successfully navigating a transition to new patterns than covered in this thesis. First of all, the trustful relationship between coach and the team should be mentioned here. Fortunately, there is ample research covering this (Adkins, 2010; Andersen & Katz, 1990; Dierolf, 2013; Drath, 2012; Edding & Schattenhofer, 2020; Stober & Grant, 2010; Zumkeller, 2010), providing learnings relevant for team coaching, including the DSC.

The communication report and the DSC coaching process are explained in depth in paper 1.

3.3 Research gap

Various aspects of online communication have been analyzed and visualized to understand team collaboration. However, a team coaching process using online visualizations of communication metadata represents a novel approach. There is no previous research on how data driven visualization of communication patterns can help teams to reflect and improve their collaboration. Neither is there an algorithm published on how to use communication metadata to infer a social network analysis from online video conferences.

This leaves room for new possibilities for analyzing and visualizing team communication. The potential benefits for teams and organizations in filling this gap include improved social well-being and more effective collaboration.

A further potential benefit lies in providing a basis for new mixed method research designs. Such designs could enable comparisons between the subjective perspectives of team members or external observers and the quantitative social network analysis.

3.4 Research objectives

The research objectives -aimed at supporting teams that collaborate through video conferences in improving their communication by means of ICT and the targeted application of human-centered design principles- are divided into the following areas:

1. How do ICT tools and processes have to be constructed to effectively help teams to improve their communication by reflecting their communication patterns?
2. How can teams learn about their team positions and about their leadership by reflecting their communication patterns in a digitally supported team coaching process?
3. What are necessary criteria for a university course to support self-organized online learning?

These research objectives were addressed in the papers listed in Table 1. Each paper contributes findings that either highlight different aspects of the objectives or examine them within distinct social contexts.

Paper	Research objectives	Title	Publication Venue	Research-focus and -methods
1	1 and 2	Developing Teams by Visualizing Their Communication Structures in Online Meetings.	Multimodal Technologies and Interaction Journal	Explaining both DSC and communication report, providing theoretical basis and research context, showing the findings of evaluating the DSC in business context. A multiple case study using a replication logic for teams in three different contexts is used to identify convergent findings. Mixed methods are used in all of the cases to triangulate quantitative and qualitative findings.
2	1 and 2	Digitally supported coaching and its application to developing self-organizing teams.	Human-Intelligent Systems Integration Journal	In-depth analysis of a case study in which the DSC is used with a self-organizing team, with particular focus on what can be learned about leadership and moderation with help of the DSC. Mixed methods are applied, where quantitative data is used to help the team identify relevant findings. The quantitative data is also used to discern which of the subjective team findings can be corroborated by the social network analysis.
3	1, 2 and 3	Using digitally supported communication analysis to facilitate constructive discourse in educational Courses.	EdMedia + Innovate Learning 2023 Conference	Showing the results of two case studies, on how digitally supported coaching can be used to support group work in university courses. Here, conventional coaching and DSC are applied sequentially to find out what relevant insights the teams found in the DSC that had not come up previously.
4	1	Unveiling Communication Patterns: Helpful Visualizations of Communication in Online Video Conferences.	2024 8th International Symposium on Multidisciplinary Studies and Innovative Technologies (ISMSIT)	Showing how graphical visualizations of synchronous online communication can be formed to enable insightful reflection. The results of the design science research featuring six case studies are combined with findings of previous research to postulate criteria for the design of online communication visualizations that are used for the purpose of team reflection.

5	3	Framing self-organized online team collaboration in a higher education course on Informatics and Society.	2021 IEEE Frontiers in Education Conference (FIE) Conference	Researching how online education can be framed to facilitate both learning and social interaction. A novel online gamification approach is evaluated based on the qualitative content analysis of a survey among participants of a university course.
---	---	---	--	---

Table 1: List of Papers

4 Reference framework Digitally Supported Coaching

Large parts of the research covered in this thesis were conducted using the DSC as reference framework. The DSC was developed in a design science approach. It is a framework that features a tool that analyses and visualizes video conference metadata as part of a coaching process. The separate audio tracks of video conference meetings serve as input for this tool. To be able to evaluate the DSC in multiple case-studies, the participating teams used the tool Zoom (<https://www.zoom.com>) for their video conferences. This tool was chosen, as it allows to store recordings of video conferences in separate audio tracks. The DSC software was written by the author in Python. Python was chosen, as it provides a rich variety of libraries in the fields of data science.

The processing of the audio tracks in the DSC follows these steps (as is explained in more detail in paper 1):

1. Reading the audio data from the files,
2. Conducting a diarization for all meeting participants, capturing it in a multi-layered data-structure,
3. Inferring the social network from the diarization,
4. Visualizing the communication in various diagrams based on the diarization, compiled into the so-called communication report.

Step 3 introduces a way how a social network can be inferred from the interactions of a team throughout a series of video conferences. The algorithm and the underlying mathematical equations are published in paper 1. The resulting network can be the basis for a social network analysis (SNA).

Embedded in constructivist-systemic coaching such as the DSC, the communication report, like a hypothesis, serves as a purely observational outside view on a conversation. It is always the coachees who decide what they consider as relevant in the visualizations they are provided with. It is also entirely up to them to decide what to take away from a DSC session. Differences that make a difference in the DSC may for instance be changes in positions of team members over time or the change of the rhythm in conversations depending on whether the supervisor is present in the meeting or not. That way, a coach can use questions to guide a team through a communication report, thus potentially increasing the yield of relevant information found by team members. Through these insights, learning can be fostered, and concrete take-aways in terms of reinforcing or changing behaviour can be agreed upon by the team at the end of the DSC.

5 Methods

5.1 Preamble

A large part of this doctoral thesis makes use of the Digitally Supported Coaching. A framework that the author himself invented. In four out of five papers, the DSC is used and evaluated in different contexts regarding different aspects. The author is aware that this poses an inherent risk: A creator is typically positively biased towards his or her creation. A natural sentiment and probably a prerequisite to perseveringly drive an idea forward, overcome obstacles and deal with the innate uncertainty of any innovation process. On the other hand, any bias is detrimental to sound scientific evaluation. It is the firm belief of the author that the value of this doctoral thesis is not the invention itself, but it's scientific evaluation and the learnings that can be taken and generalized from that. Therefore, the research designs were crafted to take the inevitable creators bias into consideration and to effectively mitigate it through a bundle of measures.

Measures taken for this purpose included:

- Having independent co-researchers and -authors for the papers that are part of this thesis.
- Using mixed methods, where possible, to increase the validity of the findings.
- Trying to select and apply scientific methods meticulously to the best of the abilities of the authors to limit the influence of the researcher. E.g. using standardized questions in the DSC coaching session and for the questionnaires. That way, no case-specific questions could be asked that might convey unwarranted information by the coach.

Furthermore, as this is a cumulative doctoral thesis, all publications have undergone rigorous external peer review.

5.2 Case Study Design

Case studies were selected as main method for the empirical part of this doctoral thesis. This follows Yin's criteria for the choice of methods (Yin, 2018), as the research:

1. mainly pursues research questions asking "how" something can work,
2. focuses on contemporary events,
3. aims to examine events in real life as they unfold, not requiring control over behavioral events in the teams examined.

Furthermore, case studies provide the possibility for an in-depth analysis that helps to thoroughly examine the impact of a new framework such as the DSC.

Yin stresses the need for “spatial, temporal and other explicit boundaries” in defining a case (Yin, 2018). The cases in the different studies presented here are bound:

1. Socially, by representing a defined social system, in specific a certain team being part of a certain organization. Teams can be seen as “closed autopoietic systems—i.e., communication systems with rules that perpetuate themselves by constantly seeking new players who follow these rules.”⁴ (Kriz & Simon, 2019)
2. Temporally and spatially, by analyzing meetings that are conducted in a predefined timeframe in an also predefined (virtual) space.

It is of key importance to be aware of the context the cases are embedded in. This maxim is set both from the perspective of case study design as well as organizational system theory, as introduced by Luhmann (1978). The relevant context for the teams analyzed here first of all includes the organization surrounding it. This context can be described through its organizational culture in terms of shared values and beliefs (Schein, 2010). Values and beliefs are bound to influence how team members interact and will therefore make a difference for their communication. The organizational context is also relevant in terms of communication patterns: It is natural to assume that a team’s communication patterns are not uninfluenced by the organization surrounding it. An assumption that is coherent with the social identity theory that approaches group phenomena from a psychological perspective, intending to “explain organizational phenomena and the dynamics of language and speech style as identity symbols” (Hogg, 2016). This assumption is also at the core of organizational system theory coming from a sociological perspective (Simon, 2021). A theory that clearly distinguishes between organization and its members. In that view, all persons serving in an organization, employees and leaders alike, are seen as context of the organization. Person and organization are defined as strongly coupled but separate systems. In that view, the individual personalities of the team members are also relevant contexts for the case studies examined here.

To take this into account, the research presented here features multiple cases studies in different contexts. Paper 1 analyzes three cases in different commercial organizations. Paper 2 analyzes group interaction in a self-organized team that is part of a non-hierarchical organization. Paper 3 and 5 are conducted in educational environments. Paper 4 analyzes three cases that are set in a hierarchical organizational context and three cases that are set in non-hierarchical environments. This setup allows to A) identify commonalities in the results across different contexts, and B) identify differences in the results between hierarchical and non-hierarchical contexts.

To this avail, papers 1,3 and 4 feature multiple case studies. All of them are designed following a replication logic. While each case represents a separate unit with clearly defined boundaries, the same methods in collecting and analyzing evidence are used in all cases. First the results of the cases are reported separately, then convergent evidence is sought, following the approach suggested by Yin (2018).

Another key question in case study design is how to achieve a high validity of the findings. To this end, mixed methods were applied in the majority of the studies.

⁴ Quote translated from German to English by the author.

5.3 Mixed Methods

5.3.1 On the origin and purpose of mixed methods

It has been argued that “research methodology, and the teaching of research, has faced strong pressures toward polarizing into a qualitative and quantitative dichotomy” (Tashakkori & Teddlie, 2003). In the 1950s a path out of this supposed dichotomy was introduced: To combine different methods, “utilizing a matrix of intercorrelations among tests representing at least two traits, each measured by at least two methods” (Campbell & Fiske, 1959). Since then, a variety of mixed methods have occurred that try to combine qualitative and quantitative methods in different ways. They have been attributed as “direct descendants of classical experimentalism and the triangulation movement of the 1970s” (Denzin, 2012). Broad scientific discourse exists regarding these different mixed method approaches and their pros and cons.

Mixed methods rely on triangulation. The name of the method is inspired by geological studies, where the distance to a point can be calculated by viewing it from different perspectives. As in this simile, this scientific method aims to better assess research objects by examining it with different methods. Every method necessarily needs to reduce the complexity of reality to a manageable degree. Reality may appear uniform and consistent when seen from a certain perspective, something that can easily lead to reductionism. Triangulation aims to mitigate this risk. It can be seen as an “entrance to different levels or dimensions”⁵. (Flick, 2010). Receiving different results from such different levels, potentially forces the researchers to confront themselves with very different ways of answering the same research question. That way, the inherent simplifications of any model are challenged by a second, different model. But it also raises fundamental epistemological questions, as qualitative methods are often rooted in hermeneutic or constructivist epistemology, where else quantitative methods often follow a (neo-)positivistic understanding.

A main thinker on triangulation was Norman K. Denzin. As a result of decades-long scientific discourse, he adapted his concept of data triangulation to seek “multiple sites and levels for the study of the phenomenon in question. It is erroneous to think or imply that the same unit can be measured. At the same time, the concept of hypothesis testing must be abandoned. The interactionist seeks to build interpretations, not test hypotheses.” (Denzin, 2017). The idea proposed here is to broaden the understanding of a research object by using different methods. And to lay open and discuss the underlying assumptions that led to the respective findings.

⁵ Translated from German by the author.

5.3.2 Applying mixed methods to analyze group interactions

Mixed methods have been used to analyze group interactions. In one example, critical discourse analysis (CDA) and social network analysis have been combined to assess changes in role positions within a school class and to better understand how these group dynamics affect the learning process of the class (Huber & Froehlich, 2020). Here, mixed methods are used to create knowledge, “as something that evolves over time through participation in disciplinary practices.” In this case, the CDA, as a qualitative method conducted by outside observers, was used to better understand the learning process. The SNA was used to understand changes in structures and interactions within the group. In the interpretation of the authors of this study, the SNA could thus strengthen or question the results of the CDA.

Another study used a custom-built text-classification model to measure social presence in student groups collaborating in online forums (Zou et al., 2021). This was considered as an indication for social prestige following the framework for social presence introduced by Shea et al. (2010). As a second perspective on social positions, a social network analysis was conducted measuring in-degree centrality and the authority score of all students. This was considered to reflect the learners’ prestige of a person within that social system. Then a statistical analysis sought to detect a correlation between social presence and learners’ prestige. In this research, two different quantitative methods, with different underlying conceptual models were used. Both measured the social positions of team members, with the aim to “explore how much of the variance of learners’ prestige (both in-degree and authority scores) can be explained by social presence” (Zou et al., 2021).

5.3.3 Mixed methods used in this doctoral thesis

In this doctoral thesis, mixed methods are used for two purposes:

Firstly, to increase the validity of the findings. Following Denzin, they aim to broaden the understanding of interactions in groups by providing different perspectives. And in paper 1, they are used to strengthen the construct validity of the case studies, using the concept of triangulation.

Secondly, to best support team coaching processes with the help of ICT. Coming from a synergetics point of view, Juergen Kriz argues that in psychotherapy, both the subjective understanding of the context and the objective system-environment as perceived by an outside observer are relevant (Haken et al., 2017). The synergy of these views helps in understanding the condition of a patient, even if the two perspectives sometimes do not correlate. Kriz uses the example of asthma patients, where medical parameters and subjective feeling of the patients often draw a very different picture. Transferring this idea to team coaching, it can be proposed that a synergy of the subjective views of a team and objective information on a group process can be helpful. In case of this thesis the first view is gathered through questionnaires, the second perspective is represented

by the data received from analyzing the audio tracks. The combination of these views can help the coach and the team to better see what control parameters (in the meaning of the term as used in synergetics) can be adjusted to improve team collaboration. Control parameters in team coaching could for instance be to involve introverted persons more actively or to be more empathic in listening to one another. The first example would adjust a parameter of the group as a whole; the second parameter would adapt individual behaviour.

The research presented in paper 1 uses a mixed methods approach to increase the construct validity of the case studies conducted. In these case studies, team members deduct findings regarding their team positions from the visualizations they are presented with. The SNA provides a second, quantitative source for team positions. This allows to check how accurately team members discerned their team positions in the DSC by reflecting their communication report. The common data basis for both methods is the diarization of the group interaction. The diagrams in the communication report featured in the DSC are created out of this diarization, as is the SNA. From a methodological point of view, two different views on this data are used to examine the research proposition that “studying a team’s communication patterns can help team members to learn about their roles and their interactions within a team”: On one hand the mathematical calculations of the group interactions resulting in quantitative figures for team positions and relationships; and on the other hand the cumulative subjective interpretations of the communication reports by the team members. The latter was gathered by questionnaires and then aggregated using reflexive thematic analysis. When both views come to the same result, we can see this as indication that the research proposition can hold true. However, the reverse conclusion cannot be drawn: When both views are not coherent, it might be that the research proposition does not hold true, but it might as well have other reasons, for instance, that the process was ill-facilitated.

In paper 2, qualitative and quantitative methods were used to examine leadership in a self-organized team. The qualitative findings were gathered by means of a questionnaire at the end of a DSC session, after the team members had seen and reflected upon the communication report. The answers to the questionnaires were then processed using reflexive thematic analysis. The quantitative analysis provided metrics for team positions (through the SNA) and their change (or stability) over the course of several meetings. In the subsequent analysis, these two different views on communication were used to show in what aspects the perspective of the team members were backed up by the quantitative data.

In paper 3 mixed methods were applied in a different way. Two cases, each representing a student group’s discussion of a controversial subject in a video conference were examined. For each case, two methods of coaching were then applied sequentially to reflect the discussion. At first, a conventional team coaching was conducted. This was followed by a second phase featuring visualizations of the communication based on quantitative data. To this end, the interactions and the discussion flows were visualized in communication reports using the tool developed for the DSC. Comparing the outcomes of the two coaching phases showed what insights the teams could find in the

Digitally Supported Coaching that had not previously been recognized in the conventional team coaching.

To provide a realistic assessment, the study aimed to provide a coaching setting on a high standard in the first phase. Measures taken included:

- Each group had the chance to review the video of their group interaction at the beginning of their respective coaching process,
- silent observers were part of the video and shared their observations in the coaching process,
- each team coaching was facilitated by a lector, who was experienced in facilitating team discussions,
- these lectors prepared by reviewing and analyzing the video beforehand to provide helpful questions and other interventions.

In both phases, the answers to the predefined coaching questions were captured during the coaching process using sticky notes. That way, everything that was said was visible for all team participants and could be used for further reflection.

5.4 Quantitative Analysis

5.4.1 Data collection

Quantitative analysis in this thesis is done by analyzing the audio tracks of recorded video conferences with the help of computer science. The audio tracks were available in Moving Pictures Experts Group (MPEG)-4-Format encoded with the Advanced Audio Codec (AAC). In the DSC, these files are processed with the open-source software `ffmpeg`. This software package has been developed and finetuned over many years to provide a broad set of audio features. It has been chosen for the DSC as it allows to detect the speaking times within an audio track. Speaking times are annotated by giving the timeframes when a speech occurs on a given audio recording. The accuracy of this feature was tested by the author of this thesis by doing three test video conference recordings with different level of background noises. To increase the variety of the test, participants were using different microphones. The speaking times of these recordings were then calculated both manually with the help of a digital audio workstation (DAW), and by means of the `ffmpeg` algorithm. The deviation in the speaking times annotated between the two methods was less than 5% in all three cases.

The datasets derived from `ffmpeg`, one per participant, is then used within a python program to create a so-called diarization dataset. This dataset contains the list of meeting participants, each containing the list of speaking times for the respective participant.

The flow of this diarization process for one participant is illustrated in Figure 1. The `ffmpeg` algorithm first isolates the frequency band most indicative of human speech. It then derives the magnitude, i.e. the indication how strong this frequency band is per

time interval. It then selects those time intervals, where the magnitude is above a predefined threshold (indicated by the red line on Figure 1). This list was then analyzed by a python program, custom-built by the author, using standard python libraries, to create the diarization datasets (illustrated by the blue boxes at the bottom of Figure 1) for the social network analysis and the data visualizations.

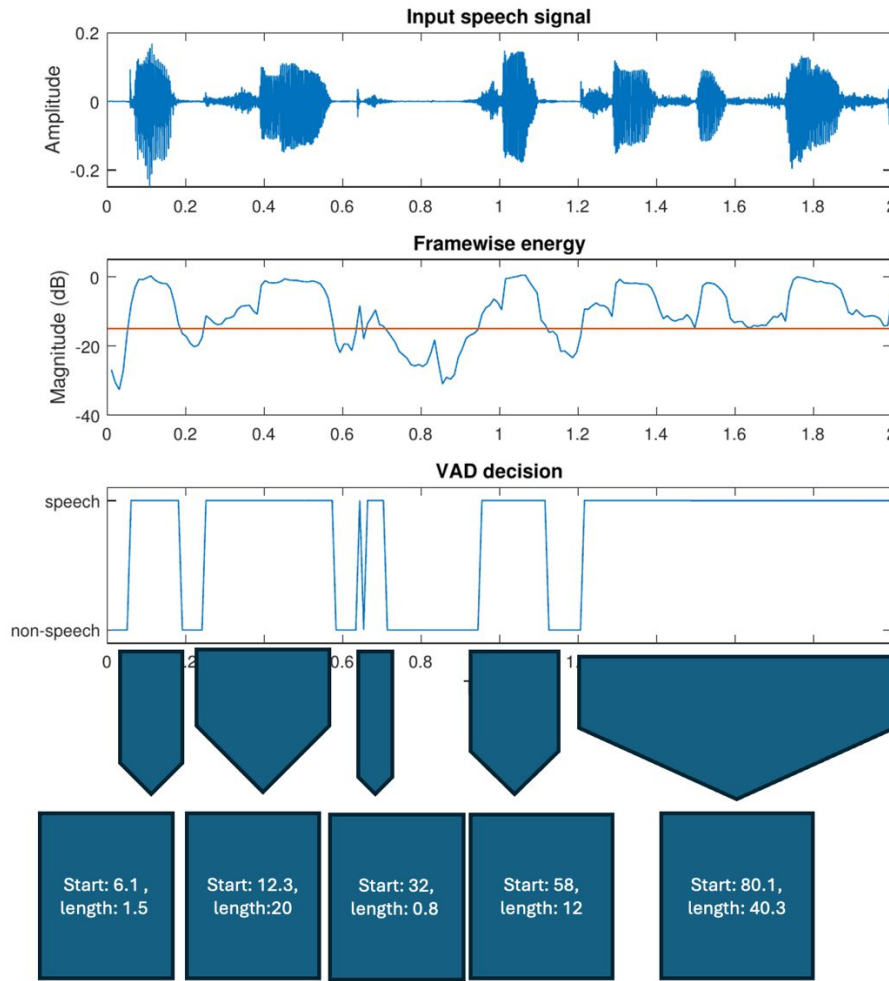


Figure 1: The diarization process (from top to bottom). VAD refers to Voice Activity Detection.

5.4.2 Social network analysis

The social network was inferred according to the algorithm introduced and published in paper 1. The diarization dataset was a sufficient basis to do so, as the speaking times of the meeting participants allowed to detect who was speaking after whom. Based on the premise derived from communication theory, such subsequent communications indicate an interaction between two persons. The choice of the mathematical formulas to compute the relevant social positions out of these interactions is discussed in depth in paper 1.

5.4.3 Data analysis

The diarization data also allowed for statistical analysis. This included analysis of individual behavior, such as speaking times of individuals. It also provided a basis to look for structural information on communication in team meetings. This included the balance of speaking times of participants (as in paper 2) over several meetings, or recurrently strong relationships between some players and weak ones among others (as in paper 1). Such recurring phenomena were indications of potential communication patterns from this quantitative perspective.

5.4.4 Data visualization

Data visualization was partly automated using standard python libraries, partly done manually:

- The airtime diagram was automatically created using the method to create pie charts from the python pandas library.
- The communication sequence diagram was automatically created as a scatter plot using the python pandas library.
- The communication interactions were calculated in python by an algorithm developed by the author, exported as CSV files, and then manually plotted as interaction diagrams in Microsoft PowerPoint.

5.5 Qualitative Methods

For the purpose of this doctoral thesis, the subjective views of meeting participants were captured using questionnaires in all of the five papers. This provided an internal view of the team members on their communication, which was used as one source of evidence.

To analyze the answers of these questionnaires two different branches of qualitative methods were pursued:

1. Reflexive thematic analysis as outlined by Braun and Clarke (Braun, 2022; Braun & Clarke, 2019)
2. Summative qualitative content analysis (Kuckartz, 2018).

The former method was used in papers one to three. The focus of these research designs was to discern the themes of the reflection of a team's communication, particularly those themes that might refer to patterns in team communication. The summative qualitative content analysis was used in paper 4 and paper 5. These research designs led to datasets of replies with more complex structures. Therefore, in these papers, codebooks, with codes and subcodes, were created to accurately reflect the structure of the dataset under examination.

The codes were created inductively as recommended by Mayring (2022). The author is aware that choosing adequate codes in qualitative content analyses is to some extent subject to individual interpretation. Therefore, in both studies the codebooks were created iteratively by two researchers. The researchers discussed and aligned their coding structure after each iteration. The results were then peer-reviewed by a third, external researcher, and adapted according to the feedback.

5.6 Design science approach

5.6.1 Why using design science research?

Research objective 1 asks how “ICT tools and processes have to be constructed to effectively help teams to improve their communication by reflecting their communication patterns”. One aspect in the construction of these ICT tools and processes is the visualization of online video conferences. Paper 4 asks how the artifacts for such visualizations can be designed in a way that is helpful for teams in discerning their communication patterns. A design science approach was used in this research to pursue this question. Design science can be seen as a “research paradigm in which a designer answers questions relevant to human problems via the creation of innovative artifacts, thereby contributing new knowledge to the body of scientific evidence. The designed artifacts are both useful and fundamental in understanding that problem” (Hevner & Chatterjee, 2010).

This approach was chosen as it can be used to discern what is relevant in the design of artifacts from the perspective of those who know best: the users of the DSC. To that avail the design artefacts in question should be “analysed as to their use and performance as possible explanations for changes (and hopefully improvements) in the behavior of systems, people, and organisations” (Venable et al., 2016). This supports the objective of paper 4 to find out what types of visual representations are most helpful in leading to changes in a team’s perceptions of its communication. Furthermore, it is used as one source to propose a first set of criteria in designing and conveying visualizations of metadata of synchronous online communication.

5.6.2 Applying design science research to visualization artifacts

The diagrams that compose the communication report were the artifacts investigated in paper 4. The research process was split into three phases based on the work of Österle et al. (2011): analysis, design, and evaluation. The first two phases were done iteratively to continuously improve the artifacts: The design was adapted after each evaluation based on the feedback received. The initial iteration was based on the feedback of fellow-researchers, which led to the first version of the communication report that was then used in DSC sessions. The feedback on this version was evaluated in a second iteration, which formed the basis for the empirical research in paper 4.

This evaluation was based on the answers given to questionnaires to the participants of the DSC, immediately after they had seen and used the artifacts for the first time.

The questionnaire asked the following questions:

1. What report is most helpful to learn about and improve your team communication?
2. What could be added / removed / changed to make this report more valuable to us?
3. Do you have other comments, suggestions, or ideas?

To address question 1, each participants had 10 voting points to distribute among the four different diagrams. The answer to this question was analyzed using quantitative methods, in specific the average percentages given per report. This was done for all six case studies together, as well as separately for the three case studies featuring hierarchical and the three case studies featuring self-organized teams. That way, commonalities and differences between the two contexts could be identified.

The answers to questions 2 and 3 were aggregated using summative qualitative content analysis as described in chapter 5.5.

6 Synopses of Publications

This chapter gives an overview of the published research conducted within this thesis by outlining the publications it contains. The complete papers are provided in Appendix A: Publications.

6.1 Paper 1: Developing Teams by Visualizing Their Communication Structures in Online Meetings

Authors:

Thomas Spielhofer (T.S.), Renate Motschnig (R.M.)

Status:

Published

Published In:

Multimodal Technologies and Interaction, 7(10), 2023

Bibliographical reference:

Spielhofer, T., & Motschnig, R. (2023). Developing Teams by Visualizing Their Communication Structures in Online Meetings. *Multimodal Technologies and Interaction*, 7(10), 100. <https://doi.org/10.3390/mti7100100>

Contributions:

Conceptualization, T.S.; methodology, T.S. and R.M.; software, T.S.; validation, T.S. and R.M.; formal analysis, T.S.; investigation, T.S.; resources, T.S. and R.M.; data curation, T.S.; writing—original draft preparation, T.S.; writing—review and editing, R.M.; visualization, T.S.; supervision, R.M.; project administration, T.S.

Summary:

This paper lays the groundwork for the research related to the DSC framework. It introduces the idea that communication patterns in online video conferences can be measured and visualized to the benefit of the teams who regularly collaborate online. It draws on systemic communication theory, foremost the work of Watzlawick et al. to illustrate the relevance of understanding communication patterns for teams. Based on this, it introduces a way to operationalize and measure communication patterns in video conferences. It then shows different ways to visualize these communication patterns, how to assemble them into a communication report and embed them in a team coaching process. This team coaching process is framed as a systemic-constructivist coaching process based on the work of Steve DeShazer and others. The paper further elaborates how a communication report can be used as an outside perspective on team communication. This is put in line with the epistemological understanding of DeShazer, based on Wittgenstein's work, that the meaning given to any insight is the result of a conversational team process. Following that approach, the DSC, as introduced here, uses the communication report as one additional perspective on communication,

based on metadata rather than on subjective views, for the team. It is offered as a chance for the team to discern for themselves what they might have previously been oblivious to and draw conclusions from it as they see fit at that point in time in that given context.

One section of the paper addresses how interaction in online video conferences can be used to infer a social network analysis that reflects the interaction of the participating team members. This undertaking is situated within the decades-long discourse on the meaning and significance of various SNA metrics, as discussed by mathematicians, sociologists, and other experts. Following that rich source of knowledge, definitions for *centrality* and *relation* are proposed for teams that collaborate via video conferences. The mathematical formulas for these definitions are presented and algorithms to measure them are described. The ability to have a quantified view on team positions and relationships based on the interaction in online meetings opens additional possibilities. For one, it allows to enrich the communication report by sociogram-like diagrams. Furthermore, it allows for a triangulation in the research design. In this case, it is used to compare the inner view of the team on relationships and team positions with the metrics for relations and centralities of the SNA.

Following the theoretical part, three case studies featuring the DSC are presented. The methods sections describe the setup of these case studies, and how convergent conclusions can be derived due to the replication logic they follow. It elaborates how qualitative findings are drawn from the questionnaires of team members after each DSC. It further shows how the quantitative and qualitative findings are combined in a mixed method approach to strengthen the robustness of the cases studies.

The results show that the three teams covered in the case had different focuses and findings in their DSC sessions:

- **Case 1:** A team of four had a leader who had most of the airtime and handled most interactions, especially with one other person in the team. The team recognized this dynamic and proposed including quieter members more actively.
- **Case 2:** Another four-person team showed balanced airtime and high interaction, particularly from the moderator. The team appreciated open communication and proposed improving efficiency and involving less-active members.
- **Case 3:** A large 19-member team displayed a hierarchical pattern dominated by a supervisor and moderator. Most communication flowed through these roles, with peripheral members minimally involved. This created substantial food for the discussions in the DSC. Suggestions taken from this reflection included balancing airtime and better integrating latecomers into the discussion flow.

The initial evaluation presented in this paper indicates that DSC-like coaching approaches, as a novel way of online team coaching, have the potential for leveraging digital tools in fostering team development in virtual environments. The research shows the benefit of visualizing communication for improving online team dynamics. It opens pathways for exploring advanced applications, such as measuring the predictors of group intelligence.

6.2 Paper 2: Digitally supported coaching and its application to developing self-organizing teams

Authors:

Thomas Spielhofer (T.S.), Renate Motschnig (R.M.)

Status:

Published

Published In:

Human-Intelligent Systems Integration, Volume 6, (2024)

Bibliographical reference:

Spielhofer, T., & Motschnig, R. (2024). Digitally supported coaching and its application to developing self-organizing teams. *Human-Intelligent Systems Integration*, 6, 91–101. <https://doi.org/10.1007/s42454-024-00056-6>

Contributions:

Conceptualization, T.S.; methodology, T.S. and R.M.; software, T.S.; validation, T.S. and R.M.; formal analysis, T.S.; investigation, T.S.; resources, T.S. and R.M.; data curation, T.S.; writing—original draft preparation, T.S.; writing—review and editing, R.M.; visualization, T.S.; supervision, R.M.; project administration, T.S.

Summary:

The research covered in this paper examines how and to what effect the DSC can be applied to self-organized teams that collaborate online -further referred to as self-organized online teams (SOOTs). It features the case-study of a self-organized team that leads a non-profit organization. This team differs from the case studies presented in paper 1, as there is no hierarchical leadership, neither within the team itself nor in the organization that it is part of. In this context, the focus of the research was on communication patterns that can shed a helpful light on the particularities of self-organization. There is broad discourse on communication and leadership in non-hierarchic social systems. They range from the visions of new forms of self-governance in society as introduced in sociocracy (Czekaj et al., 2020; Ward, 1892) through ideas of organizational designs for commercial companies in Holocracy (Robertson, 2015) to the idea of self-organized learning as a new educational paradigm (Harri-Augstein & Thomas, 2008). It was also named a core principle in agile software development, stating that “the best architectures, requirements, and designs emerge from self-organizing teams.” (<https://agilemanifesto.org/>). This research examines the potential of the DSC in bringing a new perspective to the discussion on how self-organization can work in practical day-to-day life. A perspective that is not only based on than on subjective views but also uses communication metadata. Given this context, questions regarding leadership were of particular interest of this case-study. The DSC can contribute here by visualizing certain aspects of leadership in meetings, that for instance reflect who is moderating the communication process and how centralities of team members evolve over time.

The research questions were:

- 1.1 What can SOOTs learn through the reflection of their communication structure during a DSC?
- 1.2. What can SOOTs learn about their roles within a team with the help of DSC?
- 1.3 What can SOOTs learn about their moderation with the help of DSC?

The method section of the paper elaborates how the case study was set up. Two sources of evidence were used: The quantitative metadata of the communication on one hand and the subjective views of the participants on the other. The latter was gathered by means of a questionnaire at the end of the coaching session, after they had seen and reflected upon the communication report. The answers to the questionnaires were then processed using reflexive thematic analysis. In this case, two different phases of the team collaboration were examined: three meetings that took place in 2023, and one meeting that took place in 2021. Accordingly, the team coaching session was conducted in two parts covering the different phases.

The data of the meetings in 2023 show a high variance in relative speaking times and interactions. A fact that was also discerned by the team members in their reflection in the DSC. Coherently, the social network analysis shows, that there is no single person that continuously has the highest centrality throughout all meetings. Instead, in each meeting there was a different person at the centre of the communication flow. This was further underlined by the SNA, showing that there was always only one person that had dense interactions with all other team members. This leads to the hypothesis that while there was always a clearly distinguishable leader in every meeting, this leadership role was not fixed to one person within the time period observed. Instead, leadership seems to have switched between persons, depending on the context of the meeting.

Understanding these context factors would be a valuable aim for further research. Is it rather the meeting agenda or social factors, or a combination of both, that determine which team member takes the lead?

There were other findings of the teams, including the surprisingly precise balance of airtime by two specific team members across all meetings in 2023. No matter what the topics of a meeting was, each of the two took quite precisely 25% of the overall speaking time. This served as a basis to reflect what led to this stable pattern. To this avail, group dynamic models were used to from hypotheses whether this could be a strive for team positions (Schindler, 1957) and/or two different value areas represented by the two team members seeking to have their adequate recognition by the team (Sparrer, 2009).

This case shows the potential for self-organized teams to learn about certain aspects in their communication by reflecting upon their communication patterns. In this context, the DSC particularly proved as a helpful basis to reflect meeting moderation and leadership as well as team positions. Further research could show whether there are meta-patterns that distinguish self-organized from hierarchically led teams.

6.3 Paper 3: Using digitally supported communication analysis to facilitate constructive discourse in educational courses

Authors:

Thomas Spielhofer (T.S.), David Haselberger (D.H.)

Status:

Published

Published In:

EdMedia + Innovate Learning 2023 conference. Association for the Advancement of Computing in Education (AACE).

Bibliographical reference:

Spielhofer, T., & Haselberger, D. (2023). Using digitally supported communication analysis to facilitate constructive discourse in educational Courses. In T. Bastiaens (Hrsg.), EdMedia + Innovate Learning 2023 (S. 44–53). Association for the Advancement of Computing in Education (AACE).

Contributions:

Conceptualization, T.S.; methodology, T.S. and D.H.; validation, T.S. and D.H.; formal analysis, T.S.; investigation, T.S.; resources, T.S. and D.H.; data curation, T.S.; writing—original draft preparation, T.S.; writing—review and editing, D.H.; visualization, T.S.; final review, T.S. and D.H.; project administration, T.S.

Summary:

This paper pursues the question how student team communication can be facilitated in online learning contexts by digitally supporting them in reflecting their communication patterns. The communication report of the DSC is used in a different context (a university course) and a different manner than in papers 1 and 2: Two groups of students participated in controversial discussions that were held via online video conferences. The discussions were recorded with the consent of all participants. The groups had the chance to then reflect their conversations in two phases: First without and then with the help of the communication report. This research design, featuring reflection in two separate steps, allows to show what additional insights groups can gain from studying the communication report on top of the insights coming from a traditional coaching process. To make a realistic assessment, the first reflection aimed to provide a well-conceived traditional team coaching setting featuring a variety of established techniques. This included viewing the video recording and combining the internal views of the participants with input of outside observers.

In specific, the following research questions were examined:

RQ1: How can student team communication be facilitated in university online learning contexts by reflecting their communication patterns?

RQ1.1: How can constructive communication patterns be discerned in controversial online group discussions held via video conferences?

RQ1.2: how can visualizing intra-group communication help to recognize helpful and less helpful aspects in controversial online group discussions held via video conferences?

To increase the likeliness of a controversial discussion and therefore provide more food for the subsequent reflection process, each group was formed by selecting participants of opposite sides of the opinion spectrum. Each of the two discussions was silently observed (but not moderated) by a university lector, who had the camera turned off and the microphone muted. Each lector also facilitated the subsequent group reflection he monitored. To prepare for this reflection (which was held onsite), the two lecturers reviewed both videos. An interaction sequence that appeared significant to both researchers from a group dynamics perspective was selected for further detailed analysis. The purpose was to form hypotheses regarding the intentions, motivations and reciprocal reactions of the group members. This discussion among the lecturers helped to further understand the group processes and prepare adequate questions and other interventions for the team reflection.

The method section of the paper describes the scientific approach: The quantitative metadata of the online discussions formed the basis for the communication report. In this research setting, the report was used as a tool to provide additional insights for the team reflection. These insights were collected as answers to the coaching questions in the team coaching process and stuck on a board, thus making them visible to all group members. They were then documented and analyzed using reflexive thematic analysis by the researchers. This composed the qualitative part of the research. Answers to the research questions were found by comparing the results of the reflexive thematic analysis of phases 1 and 2. So in this research design, the quantitative data served as a basis for coaching phase 2. The research findings were deducted from the qualitative analysis.

The results showed that that several aspects of the discussion were only discerned by the team members in phase 2 of the reflection, upon viewing the communication report. This included insights regarding the overall team communication, such as the detrimental impact of long monologues to fruitful team discussions. Furthermore, the value of a (self-chosen) moderator and the stimulating effect of an introductory round where everyone has the floor for an initial statement were noted. Insights also concerned individual behaviour, for instance expressing that viewing the communication report “changes the perception of one owns behaviour in the discussion”.

The communication report was also a fruitful discussion ground for one group where a group dynamic of a storming-like pattern occurred. The communication sequence diagram clearly showed drastic shifts in the communication during the meeting. This was discussed in the reflection leading to several insights: The group appreciated the value of a person taking a position that is strongly contrary to the rest of the group. It recognized how that energized the group discussion. But the group also acknowledged the downside of such an open omega role (Schindler, 1957), in so far, as this person became dominant to the discussion and others remained silent.

Based on these results, the paper concludes that viewing the communication report made a difference that made a difference for the reflection process in this educational setting. It could be insightful to monitor the group dynamics of student teams over several meetings with the help of the communication report in further research. That way, it could be assessed how regular digitally supported reflection can potentially improve collaboration in educational formats that feature longer-standing teams.

6.4 Paper 4: Unveiling Communication Patterns: Helpful Visualizations of Communication in Online Video Conferences

Authors:

Thomas Spielhofer (T.S.), Renate Motschnig (R.M.)

Status:

Published

Published In:

2024 IEEE 8th International Symposium on Multidisciplinary Studies and Innovative Technologies (ISMSIT)

Bibliographical reference:

Spielhofer, T., & Motschnig, R. (2024). Unveiling Communication Patterns: Helpful Visualizations of Communication in Online Video Conferences. 2024 8th International Symposium on Multidisciplinary Studies and Innovative Technologies (ISMSIT), 1–6.

Contributions:

Conceptualization, T.S.; methodology, T.S. and R.M.; validation, T.S.; formal analysis, T.S.; investigation, T.S.; resources, T.S. and R.M.; data curation, T.S.; writing—original draft preparation, T.S.; writing—review and editing, R.M.; visualization, T.S.; supervision, R.M.; project administration, T.S.

Summary:

This paper turns to the question on how communication metadata of team collaboration in video conferences can be visualized in a way to effectively support team reflection. More specifically, it examines structural visualizations of communications, as are used by the DSC. It strives to propose an initial set of criteria for creating helpful visualizations of communication for teams that are (at least partly) collaborating online. It is based both on general guidelines taken from previous work, and findings specific to digitally supported team coaching gathered from participatory design science research. This research was conducted with six case studies, partly using the same online meetings that were featured in previous publications but with different data, specifically collected for this research.

Insights on how structural metainformation on team communication can be visualized was found in various sources. Most fundamentally in Ludwig Wittgenstein's early work, the *Tractatus Logico Philosophicus* (Wittgenstein, 2014), in which he attempted no less than an epistemological framework for describing the world. Even though he acknowledged that this attempt necessarily had to fail in the absoluteness of its aspiration, he points out, that it is in this very failure where advancement of understanding can be found in his so-called Ladder Metaphor ("Leitermetapher"). One of the lasting elements that Wittgenstein provided us with is his Picture Theory of Language ("Abbildtheorie der Sprache"). It sets fundamental criteria that any visual representation should comply with to compose an accurate reflection of real-world phenomena. Following these thoughts can help in finding a form of visualization that

preserves the real-world structure it seeks to represent. Guidelines more pertinent to this research were found in the often-cited works for data visualization such as (Tufte & Graves-Morris, 2014) and (Kirk, 2019). Given the richness of information inherent to a one-hour meeting between human beings, guidelines on how to visualize complex data structures were of particular interest. These works (and others) formed one source for the criteria for visualizing communication metadata.

The second source was the feedback to the visualizations given by participants of DSC sessions. This input was gathered as part of the participatory design science research, aiming to learn about and improve the visualizations involving beneficiaries of the DSC. The artifacts investigated in this research were the diagrams that composed the communication report. As these artifacts were both complex and innovative, case studies were chosen as a method to provide a mean for in-depth analysis. Six case studies from different organizational contexts were selected. Of these, three worked in hierarchical organizations, the other three were self-organized teams. The visualizations were evaluated using questionnaires that were filled out anonymously by the team members after the DSC team coaching. The questions were designed to assess which of the four visualization types the communication report features was considered to be most helpful. Furthermore, it was asked what changes could be made to improve the diagrams from the perspective of their users.

The results showed that the perceived value of each diagram strongly varied with the team members and their context. Each diagram was rated highly by some teams and less highly by others. In their combination, they were found to be helpful both on group level and for the reflection of individual behaviour. The most complex diagram in terms of information and structure is the “the pattern in interaction diagram”. It has the potential to show patterns in the social network over the course of several meetings. This diagram was significantly considered as more helpful by self-organized than by hierarchically led teams. This led rise to the hypothesis that this sociogram-like visualization is of special interest to self-organizing teams, as their leadership is strongly subject to a group-dynamic process. Therefore, information that helps to reflect this process might be of particular value to any team that has no defined formal leader.

These findings indicate that it does make sense to provide a variety of different views on communication in reports used for team coaching. Each visualization can represent different aspects of communication, such as the rhythm of communication or the roles and interactions of the team members. That way the innate complexity of communication can be mastered by looking at communication from different perspectives. Complexity can also be found in the variety of social contexts in which these reports may be used as well as the individual personalities and knowledge of the recipients. Therefore, another key finding of the paper is that the process of conveying the report to the recipients should be tailored to the organizational context and the previous knowledge and needs of the respective participants.

6.5 Paper 5: Framing self-organized online team collaboration in a higher education course on Informatics and Society

Authors:

Thomas Spielhofer (T.S.), David Haselberger (D.H.)

Status:

Published

Published In:

2021 IEEE Frontiers in Education Conference (FIE)

Bibliographical reference:

Spielhofer, T., & Haselberger, D. (2021). Framing self-organized online team collaboration in a higher education course on Informatics and Society. 2021 IEEE Frontiers in Education Conference (FIE), 1–9.
<https://doi.org/10.1109/FIE49875.2021.9637345>

Contributions:

Conceptualization, T.S.; methodology, T.S. and D.H.; validation, T.S. and D.H.; formal analysis, T.S.; investigation, T.S.; resources, T.S. and D.H.; data curation, T.S.; writing—original draft preparation, T.S.; writing—review and editing, D.H.; visualization, T.S.; final review, T.S. and D.H.; project administration, T.S

Summary:

This paper was the first research done in this doctoral thesis. It means to explore helpful frames for online collaboration before researching tools and processes as was done in the subsequent papers. In specific, paper 5 examines what kind of framework can be helpful to support online learning in university courses. It sets a particular focus on the social level of learning, as this is bound to suffer when teaching is moved from onsite to online formats. An effect that many experienced in the wake of the Covid-pandemic in the year 2020, the time-period in which this research was conducted. It applies the ideas of self-organized learning, a concept that stems from the 1970s, to the context of undergraduate university teaching in online video conferences. This approach follows the underlying assumption that self-organized learning, with a high degree of student interaction in different group-settings, has the potential to provide fruitful grounds for the social fabric to develop. An assumption that is based on research conducted from the 1970s to the present (Coombs & Smith, 1998; Harri-Augstein & Thomas, 2008; Hulshult, 2019; Magana et al., 2018). The research goal was to find out how a university course can be framed to support such self-organized-online-learning (SOOL).

The research questions were:

RQ1: How can a university course be arranged to support self-organized online learning (SOOL)?

RQ1.1: What are the relevant factors in the frame of the course to enable SOOL?

RQ1.2: What infrastructure is necessary for successful SOOL?

The case was composed by a university course with 38 students. This course was conducted by adapting a gamification format that relies on self-organized team-work to this context: the epic bedtime story (<https://tastycupcakes.org/2014/06/epic-bedtime-story/>). A game that is designed to let teams work together on a common outcome, in case of this university course a document on one of the topics of the course. To achieve this result, students need to collaborate within their teams as well as in between teams. It for instance requires clarification of roles and how to divide work within teams. It also needs alignment between teams on overall aspects to provide coherent content throughout the chapters and a consistent styleguide. The researchers and authors of the paper transposed the game to an online format to make it suitable for teaching based on video conferences.

The container-differences-exchange (CDE) model (Eoyang, 2012) served as further guidance on how self-organized work could be framed. In combination with other research, it provided an understanding what was important in the role of the lectors facilitating SOOL. This, among other things, included providing a suitable balance of different communication settings: working in teams in breakout sessions, where the teams can iteratively evolve their results, as well as communication between the teams.

The students' experience was then evaluated. Students were invited to give individual feedback on their perceptions of this time-constrained online teamwork. questionnaires were sent to the students, which were answered by 36 out of the 38 students. The seven questions asked included scaling questions to assess how well this format enabled students to learn the content of the course as well as getting to know the other students. Further questions focused on certain aspects, such as video conferencing infrastructure or what helped and hindered the students in their collaboration.

The answers to the questionnaire were then aggregated using summative qualitative content analysis. A code book was created based on thematic categories, featuring the codes, their counts as well as anchor examples. The code book was iteratively refined by the authors, and the reports were coded accordingly. This resulted in 91 codes, of which 29 had more than one occurrence and 127 subcodes.

The answers to the scaling question "how well did the way we worked together in these two sessions enable you to learn about the content of the course?" from 1 (worst) to 10 (best) resulted in a median of 8. The other scaling question "how well did the way we worked together in these two sessions enable you to better get to know your fellow students?" also resulted in a median of 8. This indicated that the learning format met its targets. The other questions provided specific hints on what mattered for the students most in finding a suitable learning environment. The most often mentioned answers related to breakout rooms being helpful in getting to know one another. Others emphasised the need for clear assignments or to consequently have the cameras of all participants turned on in group work.

Based on these results and the students' strong participation throughout the course, the paper sees clear indication that this format can be helpful to learn course contents in online university settings. Even more noteworthy is the high appreciation of the ability of this format to facilitate social contact making among students. The paper concludes by

stating the key factors to create a successful SOOL course based on these findings. They include an adequate communication design to allow for a well-balanced discussion flow and the selection of a suitable gamification approach. This should allow both for continuity in the teamwork in breakout sessions, as well as repeatedly providing room for communication in between teams.

7 Discussion

The following subchapters show the convergent findings of the 5 papers. They are structured according to the three research objectives of this doctoral thesis followed by considerations on their overall impact and effect.

7.1 Learning from communication patterns with the help of ICT

Regarding research objective 1 “How do ICT tools and processes have to be constructed to effectively help teams to improve their communication by reflecting their communication patterns?” the accumulated research presented in this doctoral thesis finds insights regarding different aspects in different contexts.

Paper 1 shows the concrete findings three teams in the context of commercial organizations had by using the DSC. The team in case 1 for instance quickly recognized that most interaction was carried out through their leader with a strong interplay between him and participant 1. Participant 3 was seen as less involved, and she considered herself as “careful to interfere”. These findings were consistent with the outcome of the social network analysis, in particular the centralities and the weight of the relations. The findings for improvements derived from that included social aspects, like bringing a certain person more into play, striving for more balanced airtimes as a moderator, as well as practical issues like preparing an agenda prior to the meeting or focusing on topics that are relevant to all participants.

Case 3 seems particularly noteworthy from an outside observer’s perspective. This case covered a DSC process with a team of 19 senior managers, all of them experienced members of the company. In the three observed meetings only two roles were of continuous relevance to conveying information, participating in discussions and making decisions: The supervisor and the moderator. Together, they consumed around two thirds of the overall airtime in every meeting. Furthermore, the highest level of interactions was between these two. This was confirmed by the SNA, showing that the strongest relation was between moderator and supervisor, being more than 50% stronger than the second strongest relation in the group. These facts were conveyed to the team by the interaction diagrams as part of the DSC. From the observer’s perspective, this first led to consternation followed by a heated discussion. Outcomes of this discussion were, among others, for the moderator to take “more care to have balanced airtimes”.

Insights regarding research objective 1 were also gained in paper 1 when looking for differences across teams. Cases 1 and 2 both covered teams of Austrian startup companies with 4 persons. Comparing the communication reports of these teams reveals structural differences in the teams’ communication. As the quantitative data shows, team 1 had one dominant speaker with more than 50% speaking time in every meeting. Speaking time in team 2 was more balanced, with an overall number of interactions seven times as high as in team 1. This is a difference, that is likely to affect

group intelligence. As previous research shows, collective intelligence in groups is strongly correlated with balanced communication (Duhigg, 2016; Woolley et al., 2010).

Paper 2 explores the same research objective in a self-organized context. In the case study covered here, many of the teams' insights were related to their group dynamics. They for instance reflected upon the surprising balance of communication in terms of airtime between two participants. A balance that was continuously held with astonishing precision throughout different meetings covering different topics. That raised the question what kept this pattern alive. A question that was pursued by the team finding their answers as part of the DSC. This example shows that the communication report can inspire relevant discussions on group dynamic level.

Paper 3 examines how team communication can be improved in educational context through the reflection of communication patterns. This research compared the outcomes of conventional coaching and the subsequent DSC. The convergent findings of the two case studies were that several aspects of the discussion were only noted by the team after viewing the communication report. This for instance included the insight that long discussions are detrimental to the discussion flow. It also included insights regarding the social structure of the group, such as identifying a group within the group that is interacting a lot and other participants who are mostly standing on the side-line.

Paper 4 approaches the question how ICT tools need to be constructed from the perspective of designing the visual artifacts. Results firstly showed that all four diagram types were valued for the purpose of reflecting their collaboration by some of the teams. Secondly, that teams in different contexts rated the value of diagram types quite differently. A tendency among the six case studies showed self-organized teams appreciating the sociogram-like interaction diagram far more highly than hierarchically led teams. This particularly occurs when the Interaction Diagrams of several meetings are shown beside one another. This so-called Patterns in Interaction Diagram was given an average of 47% of the votes for being the most helpful diagram by self-organized teams. In comparison, this diagram type was given only an average of 27% of votes by hierarchically led teams. Together with the findings of paper 2, this gives rise to the believe that these sociogram-like visualizations are particularly helpful in discerning patterns regarding (informal) leadership.

These results indicate that (organizational as well as individual) context play a significant role in how visual artifacts are perceived. Paper 4 therefore advocates to provide a variety of communication visualizations for the purpose of reflecting team collaboration. It also recommends to custom-tailor the process in which these artifacts are conveyed to the respective social context. In this, the paper appreciates the richness and complexity of human communication. Following previous research (Kirk, 2019), it encourages to not shy away from the complexity some diagram types might impose on some recipients (from their perspective). Because this might be the very diagram type that is most useful to others. Instead, the team coaching process should take context factors such as the hierarchy of an organization or the individual prior knowledge of the participants into consideration. That way, adequate emphasis can be put on explaining the background and meaning of diagrams in each context.

7.2 Learning about roles and leadership

Regarding research objective 2, “How can teams learn about their team positions and about their leadership by reflecting their communication patterns in a digitally supported team coaching process?” papers 1, 2 and 3 provided meaningful insights.

The third case in paper 1 showed that communication patterns in a team can prevail even when the moderation role switches from one person to another: The same distinct communication pattern occurred in separate meetings with different persons serving as moderator. In every meeting, having an average of 11 senior managers as participants, moderator and supervisor jointly had more than half of the airtime. Furthermore, the main interaction was between the two of them. The visualization of this pattern in the communication report also shows in striking clarity that the moderation pattern appears to be independent from the individual personality who acts in this role. An aspect that is in line with Luhmann’s organizational system theory (Luhmann, 1978).

Paper 2 examines what SOOTs can learn about their roles within a team with the help of DSC. The results show that meeting moderation was a recurring topic. When asking what team members noticed about their roles, one theme was “Moderation role changes as reflected in the communication report”. This switch of role between persons, was keenly discussed in the reflection part of the DSC, as the thematic content analysis shows. Apparently, this was an important subject for the team. It formed two out of three themes in answering the question what could improve the teams’ collaboration: Firstly, to keep the habit of rotating the moderation role and secondly, to define this role more clearly. This supports the hypothesis that leadership can be associated with moderation, particularly in self-organized teams. In absence of a formal captain at the helm, this could be the most apparent form of leadership in a self-organized-online-team: to steer the discussion process.

Paper 3 examined a self-organized group setting as well, this time in an educational context. Case 1 showed that studying the communication report can help in reflecting one’s own role in the process. One theme of the qualitative analysis stated that “one’s own speaking behaviour (length, concise style, degree of participation) becomes overt”. Another, being more specific, pointed out that “long monologues are detrimental to the discussion flow”.

Case 2 showed the impact a “game maker” (as one participant termed it) can have on the discussion: A participant that takes most of the airtime in some phases of the discussions. The group emphasised this when studying the visualizations of airtime distribution and interaction diagram. In their reflection, they found both the upsides and downsides such a “game maker” can have on the group discussion: On one hand the value of taking a position contrary to the group consensus and expressing this opinion openly and vehemently; On the other hand, that such behaviour contributed to others staying more passive. Furthermore, the group in case 2 appreciated the value of the (self-instated) moderator. “Moderator ensures flow of discussion”, occurred as one theme. They also recognized the importance of the moderator staying neutral. From an

outside perspective it comes as no surprise that a moderator is particularly appreciated in heated discussions, as case 2 apparently was. And that it was of less concern to the group in case 1.

Most noteworthy in the light of the research objective seems the fact that all these insights in paper 3 were only found after studying the communication report. The prior sessions of reliving the discussion by viewing the video and reflecting it with the help of a facilitator and external observers did not yield such results in either of the cases. This shows the difference such a communication report as part of a structured coaching session can make in effectively reflecting roleplay in educational group work.

Following the concept of SNA as defined by Huber & Froehlich (2020), the convergent findings of these papers can be clustered into a structural and individual level:

I) Aspects of the structural level, referring to the roleplay of the entire group. For instance:

1. **The interplay between supervisor and moderator.** The strong dominance of the axis of moderator and boss in the jour fixe of a management team. Out of 19 persons, of which 11 attended on average, they managed to keep most of the airtime to themselves. Studying the interaction and communication sequence diagrams, the team could quickly discern that the moderator mostly interacted with the supervisor. Following this insight, the team also found ideas how to mitigate this dominance.
2. **The interplay of informal roles in self-organized teams.** The balance of airtime between persons, who each represent different (informal) roles within a self-organized team. Resulting into a reflection what each of these roles stand for and why they keep each other's presence in the team meetings at bay.
3. **The role of an omega in teams.** For example, a game-maker (as the team called in the reflection) in a controversial discussion among students. When reflecting the communication report, the group exchanged their thoughts regarding the effect of this role.
4. **Moderation.** Identifying and reflecting moderator roles was a relevant topic in several cases.

II) The individual level, particularly including:

- **The function a person has for the group.** In case 2 of paper 1 for instance the team found that one person "acts like a hub between different people with different areas of responsibility".
- **The effect of one's own behaviour on a group discussion.** This for instance includes the finding of group 1 in paper 3 that long monologues are detrimental to the discussion flow.

We can therefore see the ability of a DSC-like framework to identify relevant aspects of roleplay both on group and individual level as a main convergent finding of the twelve case studies. Apparently, and perhaps not surprisingly, the pattern in interaction diagram serves as a particular good basis for reflection regarding roles. It is inspired by the sociogram created by Moreno (1941), which by now has more than 80 years of tradition in the analysis of team positions as well as in different coaching formats. It is

also worth noting that, as far as can be concluded from six of the case studies presented here, self-organized teams value this diagram type more than hierarchically led teams do. Given that SOOTs do not have a formal leadership, it does not seem far-fetched to surmise that they are particularly focused on understanding their informal leadership dynamics. This is supported by the themes of the DSC discussions in paper 2 and the rating of visualization types in paper 4.

7.3 Supporting self-organized online learning

Research objective 3 focuses on the necessary criteria for a university course to support self-organized online learning.

Paper 3 pursues this question with focus on reflecting and learning from students' group work. In specific, this research examines how their collaboration can benefit from reflecting their communication patterns. The cases examined here cover group discussions in a self-organized online learning setting. In these cases, group discussions that were reflected with the help of the communication report as part of a DSC specially tailored for this context. The results show that students found meaningful insights in both case studies, both on group and individual level. This is an indication that digitally supported coaching is one effective way to support regular reflection in student-teams to improve collaboration.

Paper 5 examines this research objective by asking what kind of frame can be helpful to support online learning in university courses. The gamification approach examined in this case study allowed learning in small groups as well as interactions between these groups. The evaluation showed promising feedback to this approach. The answers to the scaling questions "how well did the way we worked together in these two sessions enable you to learn about the content of the course?" and "how well did the way we worked together in these two sessions enable you to better get to know your fellow students?" both resulted in a median of 8 (1 being worst and 10 being best). These results indicate that the approach presented here can be an adequate frame for online teaching. This goes for university courses having too many participants to work in a single group the entire time, as evaluated here.

The potentially most relevant finding of this research might be the high ability of this format to facilitate social contact making among students. Given the shortcomings of online collaboration mentioned in the introduction, this might be an approach worth pursuing in learning environments where personal attendance is difficult.

7.4 Impact and effects

This research shows technology enhanced ways to improve online collaboration of teams collaborating in video conferences. It further shows the potential of analyzing and visualizing metadata to use it as basis for reflection and improvement of the online

collaboration of teams. The altogether twelve case studies examining the DSC in different contexts with different research designs lead to several convergent findings: First of all, that a communication report, in reflecting the structure of communication based on quantitative metadata, can inspire meaningful discussions about team collaboration. Secondly, that these discussions have the potential to yield tangible findings both on group and on individual level. That indicates that, as the research proposition suggests, discerning communication patterns in a team can help the team to improve their communication. This can also be relevant for team performance, as previous research has shown that certain communication patterns correlate with collective intelligence (Duhigg, 2016; Woolley et al., 2010).

The evidence at hand provides indication how ICT tools and processes can be constructed to achieve such team learnings. The participatory design research published in paper 4 sheds light on what can be helpful in conveying communication patterns through reports from a visualizations point of view. It takes the innate complexity of human communication into regard and suggests meeting this complexity with complexity: To provide a bouquet of alternate visualizations, each providing different views on communication. It also encourages to take time to understand and prepare for the social context in which a communication report is presented. That way, the process of explaining the different diagrams and their background can be tailored to the respective needs. Furthermore, it provides criteria on how to select and structure visual artefacts. These criteria also help to distinguish what diagram types tend to be more helpful to self-organized and hierarchically led teams, respectively.

To understand the effect a tool and a process can have on social systems such as teams, sociopsychology is certainly one relevant perspective. Coming from that view, it is remarkable what one participant in a DSC said: The report reflects and confirms feelings team members already had, but which they were too uncertain of to openly express them in a group. This is coherent with the observations of the DSC facilitators. We may therefore surmise that a communication report can help to express relevant gut feeling that might otherwise remain unheard. Transferring the underlying ideas to Denzin's Triangulation 2.0 (Denzin, 2012), to coaching, we could say that DSC is a form of mixed-method team coaching. According to this understanding, the findings in a coaching that are most worthy to be considered are those, where subjective views of team members match the quantitative analysis of the metadata.

Another related concept that is helpful to further understand the value a DSC can bring is the so-called psychological safety. This term was initially introduced by Edgar Schein and discussed in the (then new field) of organizational psychology (Aram, 1965; Schein, 1980, 2015). It was further refined and evaluated in a multimethod field study by Amy Edmondson. Edmondson understands psychological safety as a "shared belief held by members of a team that the team is safe for interpersonal risk taking" (Edmondson, 1999). Psychological safety can be considered as highly relevant for teams and organizations, not only in term of the well-being of their members, but also in terms of performance. Google, for instance, found in its project Aristotle that "research on psychological safety pointed to particular norms that are vital to success" (Duhigg, 2016). Based on this understanding, we may assume that a DSC is the more helpful, the higher psychological safety in a team is. Further research could address a potential

reciprocal effect: In how far the DSC can contribute to increase psychological safety, by providing safer grounds to express what would have otherwise been unspeakable.

7.5 Limitations

This research was conducted with a limited number of case studies, all taking place in a Western-dominated culture. The author would be excited about broadening his horizon by exploring a culturally more diverse setting and its effects in future research. Furthermore, only two persons have facilitated DSC sessions so far. More research with different DSC coaches would help to find out more about the potential influence of the coach and their relationship with the respective team on the participants' learning outcomes and social effects.

8 Conclusions

8.1 What we can learn from this research

The convergent findings show that the process used in the DSC led to meaningful insights in the different contexts examined. Therefore, we can cautiously and with confidence propose that this process can serve as a good basis for different applications of digitally supported coaching. Adaptations to different cultural and organizational contexts would be necessary when applying it. As elaborated in chapter 3.2.5, the DSC is an approach that straightforwardly follows established constructivist-systemic coaching principles. Following the underlying epistemological principles of constructivist-systemic coaching, it does not entice participants to regard the communication report in the DSC as *the* reality. Instead, it is regarded as an additional view on reality. A view that is constructed with a different kind of complexity-reduction than the one innate to human perception. In this perspective, ICT serves by providing a complementary feature to a team coaching process. This is in line with the Vienna Manifesto of Digital Humanism, as the communication report in the DSC strives to enrich the understanding of team communication, while leaving it to the human beings involved to decide what to make of it.

Another perspective on how online collaboration can be well supported by ICT is taken by papers 3 and 5. The convergent findings show the relevance of properly framing online collaboration in education. A key success factor was the interactive gamification approach that encouraged self-organized learning. Different communication formats that were designed to support the workflow were also considered as very helpful by the students. In addition, the research shows how DSC-like frameworks can be used as a tool to support the online collaboration of student teams, particularly when analyzing and learning from heated discussions.

8.2 Outlook

There are several potentially rewarding avenues to build on and extend this research. Based on the results of the DSC case studies and the feedback received in the participatory design research, the following seem particularly promising:

1. **Extend this research.** Future studies should expand the sample size, explore different cultural settings, and assess long-term impacts of the approach.
2. **Team performance.** The studies mentioned in chapter 3.2.2 point out that certain communication patterns correlate with team performance. Research beyond this thesis could explore how the DSC could contribute to recognizing and improve performance-relevant aspects in communication.
3. **Team coaching.** Providing a quantitative view on the structure of team communication can be used in further ways to support team coaching. For example, by helping to make group conformity visible and debatable. Recognizing even simple facts in groups is typically subject to some degree of group conformity. This has been shown in psychological studies such as the Asch experiment (Larsen, 1974). Providing a quantitative, hard to dispute view on the communication dynamics in the group can make a difference in making this social phenomenon discernable and debatable. The current version of the communication report would have to be extended for that purpose.
4. **Supporting online education.** The approaches evaluated in paper 3 and 5 only explore a small set of possibilities how to frame and support online learning at universities. Further research could explore various tangents on how to adapt this baseline to different cultural contexts, learning formats, or learning levels of the students.
5. **Inclusivity of teams.** Previous research has shown that “inclusivity promotes unity (by decreasing modularity), efficiency and robustness” in organizations (Moore et al., 2021). The research in this study was based on social network analysis conducted on organizational level. The doctoral thesis presented here, on the other hand, features an algorithm how to infer a SNA from a video conference (as published in paper 1). This could be used in further studies to examine whether the method applied by Moore et al. can be transferred from organizational to team level. If successful, this could potentially find broad application, as the SNA of online team meetings is fully automatable, if the algorithm developed for this thesis is extended accordingly.
6. **Exploring group dynamics.** In further research, analyzing roleplay could also be conducted with additional mixed method approaches: Outside observers could be included to provide an additional perspective. Providing their subjective outside observations might be valuable as a third view in the analysis of group dynamics. Another option would be to use observers trained in critical discourse analysis or other relevant qualitative methods. This could potentially shed further light on how social interaction in online team collaboration correlates with the topics discussed. That way, a more comprehensive view on team communication can arise, examining both communication levels as defined by Watzlawick et al. (2011): The content and the relationship levels.

8.3 Personal conclusions

The author of this doctoral thesis hopes to provide a small contribution on how ICT can be used in a way that supports collaboration and social cohesion in teams. It comes from the desire to add to the many ways in which computer science can serve in an ethically and socially sound way. To do this is personally particularly rewarding at a time where the Internet is seen by some as fathoming social divide and where dystopian visions occur of how artificial intelligence will drive us into a post-humanistic world.

What better way in such a situation, than to establish a digitally-humanistic alternative, as some great minds have begun to do. To evaluate possibilities to support human collaboration in online settings as done in this research intends to further this cause - be it by using the DSC or by combining standard tools with gamification approaches for online education. Aspiring to evaluate these ideas in a scientifically prudent way seemed and seems like the right approach. Particularly at a time where “truth”, as conveyed by some new forms of media outlets, seems to be increasingly disconnected from the evidence at hand.

This contribution would have been entirely impossible without the kind and unwavering support of the people mentioned in the acknowledgements.

We cannot choose the time we live in. All we have to decide is what to do with the time that is given us.

9 Bibliography

- Adkins, L. (2010). *Coaching agile teams: A companion for ScrumMasters, agile coaches, and project managers in transition*. Addison-Wesley.
- Andersen, T., & Katz, A. (1990). *Das reflektierende Team: Dialoge und Dialoge über die Dialoge*. Verl. Modernes Lernen.
- Aram, J. (1965). Organizational Psychology, by Edgar H Schein. *Industrial Management Review*, 7.
- Bateson, G. (2000). *Steps to an ecology of mind: Collected essays in anthropology, psychiatry, evolution, and epistemology*. University of Chicago press.
- Bavelas, A. (1950). Communication patterns in task-oriented groups. *The Journal of the Acoustical Society of America*, 22(6), 725–730.
- Bonacich, P., & Lloyd, P. (2001). Eigenvector-like measures of centrality for asymmetric relations. *Social Networks*, 23(3), 191–201. [https://doi.org/10.1016/S0378-8733\(01\)00038-7](https://doi.org/10.1016/S0378-8733(01)00038-7)
- Braun, V. (2022). *Thematic analysis: A practical guide* (1st edition.). SAGE Publications Ltd. <https://app.talis.com/textbooks/9781526417305>
- Braun, V., & Clarke, V. (2019). Reflecting on reflexive thematic analysis. *Qualitative Research in Sport, Exercise and Health*, 11(4), 589–597. <https://doi.org/10.1080/2159676X.2019.1628806>
- Campbell, D. T., & Fiske, D. W. (1959). Convergent and discriminant validation by the multitrait-multimethod matrix. *Psychological Bulletin*, 56(2), 81.
- Coombs, S. J., & Smith, I. D. (1998). Designing a self-organized conversational learning environment. *Educational Technology*, 38(3), 17–28.
- Cooper, C. D., & Kurland, N. B. (2002). Telecommuting, professional isolation, and employee development in public and private organizations. *Journal of Organizational Behavior: The International Journal of Industrial, Occupational and Organizational Psychology and Behavior*, 23(4), 511–532.
- Czekaj, J., Walczak, M., & Ziebigki, B. (2020). Towards the sociocratic organization model. *Przegląd Organizacji*, 10, 13–19.
- De Shazer, S. (1988). *Clues: Investigating solutions in brief therapy*. WW Norton & Co.
- De Shazer, S. (1991). *Putting difference to work* (1st ed). Norton.
- Denzin, N. K. (2012). Triangulation 2.0. *Journal of Mixed Methods Research*, 6, 88. <https://doi.org/10.1177/1558689812437186>
- Denzin, N. K. (2017). *The research act: A theoretical introduction to sociological methods*. Routledge.
- Dierolf, K. (2013). *Lösungsfokussiertes Teamcoaching*. BoD–Books on Demand.
- Drath, K. (2012). *Coaching und seine Wurzeln: Erfolgreiche Interventionen und ihre Ursprünge* (Vol. 1338). Haufe-Lexware.
- Duhigg, C. (2016). What Google learned from its quest to build the perfect team. *The New York Times Magazine*, 26(2016), 2016.
- Edding, C., & Schattenhofer, K. (2020). *Einführung in die Teamarbeit*. Carl-Auer Verlag.
- Edmondson, A. (1999). Psychological safety and learning behavior in work teams. *Administrative Science Quarterly*, 44(2), 350–383.
- Eoyang, G. H. (2012). *Human systems dynamics: Toward a computational model*. 634–637. <https://doi.org/10.1063/1.4756214>
- Flick, U. (2010). Triangulation. *Handbuch Qualitative Forschung in Der Psychologie*, 278–289.

- Haken, H., Kriz, J., & Tschacher, W. (Eds). (2017). *Synergetik als Ordner: Die strukturierende Wirkung der interdisziplinären Ideen Hermann Hakens*. Pabst Science Publishers.
- Harri-Augstein, S., & Thomas, L. (2008). A conversational framework for self-organised learning: Modelling personal meaning for effective action in the world. In *Handbook of Conversation Design for Instructional Applications* (pp. 308–342). IGI Global.
- Healy, K., & Moody, J. (2014). Data visualization in sociology. *Annual Review of Sociology*, 40, 105–128.
- Hevner, A., & Chatterjee, S. (2010). *Design Research in Information Systems* (Vol. 22). Springer US. <https://doi.org/10.1007/978-1-4419-5653-8>
- Hogg, M. A. (2016). Social identity theory. In *Understanding peace and conflict through social identity theory: Contemporary global perspectives* (pp. 3–17). Springer.
- Huber, M., & Froehlich, D. E. (2020). *Analyzing group interactions*. Routledge.
- Hulshult, A. (2019). Using eight agile practices in an online course. *Quality. Journal of Higher Education Theory and Practice*.
- Kennedy, H., & Hill, R. L. (2018). The feeling of numbers: Emotions in everyday engagements with data and their visualisation. *Sociology*, 52(4), 830–848.
- Kirk, A. (2019). *Data visualisation: A handbook for data driven design* (Second edition). SAGE.
- Kriz, J. (2013). Person-Centered Approach and Systems Theory. In J. H. D. Cornelius-White, R. Motschnig-Pitrik, & M. Lux (Eds), *Interdisciplinary Handbook of the Person-Centered Approach* (pp. 261–275). Springer New York. https://doi.org/10.1007/978-1-4614-7141-7_18
- Kriz, J., & Simon, F. B. (2019). *Der Streit ums Nadelöhr: Körper, Psyche, Soziales, Kultur. Wohin schauen systemische Berater?* (M. Ohler, Ed.; Erste Auflage). Carl-Auer Verlag GmbH.
- Kuckartz, U. (2018). *Qualitative Inhaltsanalyse: Methoden, Praxis, Computerunterstützung* (4. Auflage). Beltz Juventa.
- Landherr, A., Friedl, B., & Heidemann, J. (2010). A Critical Review of Centrality Measures in Social Networks. *Business & Information Systems Engineering*, 2(6), 371–385. <https://doi.org/10.1007/s12599-010-0127-3>
- Larsen, K. S. (1974). Conformity in the Asch experiment. *The Journal of Social Psychology*, 94(2), 303–304.
- Lim, V. K., & Teo, T. S. (2009). Mind your E-manners: Impact of cyber incivility on employees' work attitude and behavior. *Information & Management*, 46(8), 419–425.
- Luhmann, N. (1978). *Organisation und Entscheidung: 227. Sitzung am 18. Januar 1978 in Düsseldorf*. <http://link.springer.com/openurl?genre=book&isbn=978-3-531-07232-6>
- Magana, A. J., Seah, Y. Y., & Thomas, P. (2018). Fostering cooperative learning with Scrum in a semi-capstone systems analysis and design course. *Journal of Information Systems Education*, 29(2), 75–92.
- Majeed, S., Uzair, M., Qamar, U., & Farooq, A. (2020). Social Network Analysis Visualization Tools: A Comparative Review. *2020 IEEE 23rd International Multitopic Conference (INMIC)*, 1–6. <https://doi.org/10.1109/INMIC50486.2020.9318162>
- Martin, L., Hauret, L., & Fuhrer, C. (2022). Digitally transformed home office impacts on job satisfaction, job stress and job productivity. COVID-19 findings. *Plos One*, 17(3), e0265131.
- Massey, A. P. (2003). Because Time Matters: Temporal Coordination in Global Virtual Project Teams. *Journal of Management Information Systems*, 19(4), 129–155. <https://doi.org/10.1080/07421222.2003.11045742>
- Mayring, P. (2022). *Qualitative content analysis: A step-by-step guide* (1st edition.). SAGE Publications Ltd. <https://app.talis.com/textbooks/9781529766738>

- Midway, S. R. (2020). Principles of Effective Data Visualization. *Patterns*, 1(9), 100141. <https://doi.org/10.1016/j.patter.2020.100141>
- Moore, J. M., Small, M., & Yan, G. (2021). Inclusivity enhances robustness and efficiency of social networks. *Physica A: Statistical Mechanics and Its Applications*, 563, 125490.
- Moreno, J. L. (1941). *Foundations of sociometry: An introduction*. Beacon House. <https://ubdata.univie.ac.at/AC11980345>
- Moreno, J. L. (1996). *Die Grundlagen der Soziometrie: Wege zur Neuordnung der Gesellschaft* (Unveränderter Nachdr. der 3. Aufl.). Leske + Budrich.
- Mulki, J. P., & Jaramillo, F. (2011). Workplace isolation: Salespeople and supervisors in USA. *The International Journal of Human Resource Management*, 22(04), 902–923.
- Muszyńska, K., & Swacha, J. (2021, September). *Periodic Indicators for Graphical Monitoring of Team Communication in Information System Development Projects*. 29th International Conference on Information Systems Development, Valencia, Spain.
- Opsahl, T., Agneessens, F., & Skvoretz, J. (2010). Node centrality in weighted networks: Generalizing degree and shortest paths. *Social Networks*, 32(3), 245–251. <https://doi.org/10.1016/j.socnet.2010.03.006>
- Österle, H., Becker, J., Frank, U., Hess, T., Karagiannis, D., Krcmar, H., Loos, P., Mertens, P., Oberweis, A., & Sinz, E. J. (2011). Memorandum on design-oriented information systems research. *European Journal of Information Systems*, 20(1), 7–10. <https://doi.org/10.1057/ejis.2010.55>
- Pariser, E. (2011). *The filter bubble: How the new personalized web is changing what we read and how we think*. Penguin.
- Pavlović, J. (2021). Team Coaching Psychology: Toward an Integration of Constructivist Approaches. *Journal of Constructivist Psychology*, 34(4), 450–462.
- Pentland, A. (2014). *Social physics: How good ideas spread-the lessons from a new science*. Penguin.
- Robelski, S., Keller, H., Harth, V., & Mache, S. (2019). Coworking Spaces: The Better Home Office? A Psychosocial and Health-Related Perspective on an Emerging Work Environment. *International Journal of Environmental Research and Public Health*, 16(13). <https://doi.org/10.3390/ijerph16132379>
- Robertson, B. J. (2015). *Holocracy. The New Management System for a Rapidly Changing World*. New York.
- Rousseau, R., & Zhang, L. (2008). Betweenness centrality and Q-measures in directed valued networks. *Scientometrics*, 75(3), 575–590. <https://doi.org/10.1007/s11192-007-1772-2>
- Samrose, S., Zhao, R., White, J., Li, V., Nova, L., Lu, Y., Ali, M. R., & Hoque, M. E. (2018). Coco: Collaboration coach for understanding team dynamics during video conferencing. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies*, 1(4), 1–24.
- Schein, E. H. (1980). *Organizational psychology* (3. ed.). Prentice-Hall Internat. <https://ubdata.univie.ac.at/AC02091480>
- Schein, E. H. (2010). *Organizational culture and leadership* (Vol. 2). John Wiley & Sons.
- Schein, E. H. (2015). Organizational psychology then and now: Some observations. *Annu. Rev. Organ. Psychol. Organ. Behav.*, 2(1), 1–19.
- Schindler, R. (1957). Grundprinzipien der Psychodynamik in der Gruppe. *Psyche*, 11(5), 308–314.
- Schmid, L., Wörn, J., Hank, K., Sawatzki, B., & Walper, S. (2021). Changes in employment and relationship satisfaction in times of the COVID-19 pandemic: Evidence from the German family Panel. *European Societies*, 23, S758. <https://doi.org/10.1080/14616696.2020.1836385>

- Shea, P., Hayes, S., Vickers, J., Gozza-Cohen, M., Uzuner, S., Mehta, R., Valchova, A., & Rangan, P. (2010). A re-examination of the community of inquiry framework: Social network and content analysis. *The Internet and Higher Education*, 13(1), 10–21. <https://doi.org/10.1016/j.iheduc.2009.11.002>
- Simon, F. B. (2021). *Einführung in die systemische Organisationstheorie*. Carl-Auer Verlag.
- Sodeur, W. (2019). Bavelas (1950): Communication Patterns in Task-Oriented Groups. In B. Holzer & C. Stegbauer (Eds), *Schlüsselwerke der Netzwerkforschung* (pp. 35–38). Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-21742-6_8
- Sparrer, I. (2009). *Systemische Strukturaufstellungen: Theorie und Praxis* (2., überarb. Aufl.). Carl-Auer-Verl.
- Stadler, C. (Ed.). (2013). *Soziometrie: Messung, Darstellung, Analyse und Intervention in sozialen Beziehungen*. Springer Fachmedien Wiesbaden. <https://doi.org/10.1007/978-3-531-18981-9>
- Stober, D. R., & Grant, A. M. (2010). *Evidence based coaching handbook: Putting best practices to work for your clients*. John Wiley & Sons.
- Tashakkori, A., & Teddlie, C. (2003). Issues and dilemmas in teaching research methods courses in social and behavioural sciences: US perspective. *International Journal of Social Research Methodology*, 6, 77. <https://doi.org/10.1080/13645570305055>
- Taylor, H., Fieldman, G., & Lahlou, S. (2005). The impact of a threatening e-mail reprimand on the recipient's blood pressure. *Journal of Managerial Psychology*, 20(1), 43–50.
- Tomm, K. (1988). Interventive Interviewing: Part III. Intending to Ask Lineal, Circular, Strategic, or Reflexive Questions? *Family Process*, 27(1), 1–15. <https://doi.org/10.1111/j.1545-5300.1988.00001.x>
- Tomm, K. (Ed.). (2014). *Patterns in interpersonal interactions: Inviting relational understandings for therapeutic change*. Routledge.
- Tufte, E., & Graves-Morris, P. (2014). The visual display of quantitative information.; 1983. *Diagrammatik-Reader. Grundlegende Texte Aus Theorie Und Geschichte*. Berlin: De Gruyter, 219–230.
- Venable, J., Pries-Heje, J., & Baskerville, R. (2016). FEDS: A Framework for Evaluation in Design Science Research. *European Journal of Information Systems*, 25(1), 77–89. <https://doi.org/10.1057/ejis.2014.36>
- Ward, L. F. (1892). *Sociocracy*.
- Wasserman, S., & Faust, K. (1994). Social Network Analysis: Methods and Applications. In *Social network analysis: Methods and applications* (Vol. 8). Cambridge University Press.
- Watzlawick, P., Bavelas, J. B., & Jackson, D. D. (2011). *Pragmatics of Human Communication: A Study of Interactional Patterns, Pathologies and Paradoxes*. W. W. Norton. <https://books.google.at/books?id=YcBUAgAAQBAJ>
- Wittgenstein, L. (2014). *Tractatus logico philosophicus* (7. Aufl.). Suhrkamp.
- Woolley, A. W., Chabris, C. F., Pentland, A., Hashmi, N., & Malone, T. W. (2010). Evidence for a Collective Intelligence Factor in the Performance of Human Groups. *Science*, 330(6004), 686–688. <https://doi.org/10.1126/science.1193147>
- Yin, R. K. (2018). *Case study research and applications: Design and methods* (Sixth edition). SAGE.
- Zou, W., Hu, X., Pan, Z., Li, C., Cai, Y., & Liu, M. (2021). Exploring the relationship between social presence and learners' prestige in MOOC discussion forums using automated content analysis and social network analysis. *Computers in Human Behavior*, 115, 106582. <https://doi.org/10.1016/j.chb.2020.106582>
- Zumkeller, V. (2010). *Coaching: Grundsätze, Prozessphasen und Techniken*. Cornelsen.

10 Complete Bibliography in Alphabetical Order

- Adkins, L. (2010). *Coaching agile teams: A companion for ScrumMasters, agile coaches, and project managers in transition*. Addison-Wesley.
- Andersen, T., & Katz, A. (1990). *Das reflektierende Team: Dialoge und Dialoge über die Dialoge*. Verl. Modernes Lernen.
- Anderson, N. (2020). Examining ways COVID-19 adaptation derailed our assumptions about online learning. *2020 IEEE Conference on E-Learning, e-Management and e-Services (IC3e)*, 67–70.
- Annetta, L. A., & Cheng, M.-T. (2008). Why educational video games? In *Serious educational games* (pp. 1–11). Brill.
- Aram, J. (1965). Organizational Psychology, by Edgar H Schein. *Industrial Management Review*, 7.
- Aseniero, B. A., Constantinides, M., Joglekar, S., Zhou, K., & Quercia, D. (2020). *2020 IEEE Visualization Conference - short papers: VIS 2020: proceedings : virtual event, 25-30 October 2020*. IEEE VGTC : IEEE Computer Society, Conference Publishing Services.
- Bateson, G. (1959). Cultural problems posed by a study of schizophrenic process. *Symposium on Schizophrenia, an Integrated Approach/Ed. by A. Auerback*. NY.
- Bateson, G. (2000). *Steps to an ecology of mind: Collected essays in anthropology, psychiatry, evolution, and epistemology*. University of Chicago press.
- Bavelas, A. (1950). Communication patterns in task-oriented groups. *The Journal of the Acoustical Society of America*, 22(6), 725–730.
- Berne, E. (1964). *Games people play: The psychology of human relationships* (Vol. 2768). Penguin Uk.
- Bickman, L., & Rog, D. (2009). *The SAGE Handbook of Applied Social Research Methods*. SAGE Publications, Inc. <https://doi.org/10.4135/9781483348858>
- Biuk-Aghai, R. P. (2005). Visualization of interactions in an online collaboration environment. *Proceedings of the 2005 International Symposium on Collaborative Technologies and Systems, 2005.*, 228–235. <https://doi.org/10.1109/ISCST.2005.1553317>
- Bock, C., & Schilling, S. (2019). Autokonzern steigt auf's Gas. Schwarmorganisation bei Daimler. *OrganisationsEntwicklung*, 19/2, 19–24.
- Bonacich, P., & Lloyd, P. (2001). Eigenvector-like measures of centrality for asymmetric relations. *Social Networks*, 23(3), 191–201. [https://doi.org/10.1016/S0378-8733\(01\)00038-7](https://doi.org/10.1016/S0378-8733(01)00038-7)
- Braun, V. (2022). *Thematic analysis: A practical guide* (1st edition.). SAGE Publications Ltd. <https://app.talis.com/textbooks/9781526417305>
- Braun, V., & Clarke, V. (2019). Reflecting on reflexive thematic analysis. *Qualitative Research in Sport, Exercise and Health*, 11(4), 589–597. <https://doi.org/10.1080/2159676X.2019.1628806>
- Campbell, D. T., & Fiske, D. W. (1959). Convergent and discriminant validation by the multitrait-multimethod matrix. *Psychological Bulletin*, 56(2), 81.
- Chan, R. Y.-Y., & Zhang, Y. (2020). Collaborative Learning in Engineering Students under Social Distancing: An Action Research. *2020 IEEE Frontiers in Education Conference (FIE)*, 1–5.
- Coombs, S. J., & Smith, I. D. (1998). Designing a self-organized conversational learning environment. *Educational Technology*, 38(3), 17–28.
- Coonradt, C. A., & Nelson, L. (2007). *The game of work*. Gibbs Smith.

- Cooper, C. D., & Kurland, N. B. (2002). Telecommuting, professional isolation, and employee development in public and private organizations. *Journal of Organizational Behavior: The International Journal of Industrial, Occupational and Organizational Psychology and Behavior*, 23(4), 511–532.
- Czekał, J., Walczak, M., & Ziebiński, B. (2020). Towards the sociocratic organization model. *Przegląd Organizacji*, 10, 13–19.
- De Shazer, S. (1988). *Clues: Investigating solutions in brief therapy*. WW Norton & Co.
- De Shazer, S. (1991). *Putting difference to work* (1st ed). Norton.
- Denzin, N. K. (2012). Triangulation 2.0. *Journal of Mixed Methods Research*, 6, 88. <https://doi.org/10.1177/1558689812437186>
- Denzin, N. K. (2017). *The research act: A theoretical introduction to sociological methods*. Routledge.
- Dicheva, D., Dichev, C., Agre, G., & Angelova, G. (2015). Gamification in education: A systematic mapping study. *Journal of Educational Technology & Society*, 18(3), 75–88.
- Dierolf, K. (2013). *Lösungsfokussiertes Teamcoaching*. BoD–Books on Demand.
- Drath, K. (2012). *Coaching und seine Wurzeln: Erfolgreiche Interventionen und ihre Ursprünge* (Vol. 1338). Haufe-Lexware.
- Duhigg, C. (2016). What Google learned from its quest to build the perfect team. *The New York Times Magazine*, 26(2016), 2016.
- Dvorakova, Z., & Kulachinskaya, A. (2020). How the COVID-19 made universities switch to distance education: The Russian and Czech cases. *Proceedings of the 2nd International Scientific Conference on Innovations in Digital Economy*, 1–7.
- Edding, C., & Schattenhofer, K. (2020). *Einführung in die Teamarbeit*. Carl-Auer Verlag.
- Edmondson, A. (1999). Psychological safety and learning behavior in work teams. *Administrative Science Quarterly*, 44(2), 350–383.
- Eoyang, G. H. (2012). *Human systems dynamics: Toward a computational model*. 634–637. <https://doi.org/10.1063/1.4756214>
- Flick, U. (2010). Triangulation. *Handbuch Qualitative Forschung in Der Psychologie*, 278–289.
- Fu, X., Jar-Der, L., & Boos, M. (2017). *Social Network Analysis: Interdisciplinary Approaches and Case Studies*. CRC Press. <https://doi.org/10.1201/9781315369594>
- Gibbs, W. J., Olexa, V., & Bernas, R. S. (2006). A Visualization Tool for Managing and Studying Online Communications. *Educational Technology & Society*, 9, 243.
- Haken, H., Kriz, J., & Tschacher, W. (Eds.). (2017). *Synergetik als Ordner: Die strukturierende Wirkung der interdisziplinären Ideen Hermann Hakens*. Pabst Science Publishers.
- Harri-Augstein, S., & Thomas, L. (2008). A conversational framework for self-organised learning: Modelling personal meaning for effective action in the world. In *Handbook of Conversation Design for Instructional Applications* (pp. 308–342). IGI Global.
- Haselberger, D., & Spielhofer, T. (2020). Privacy Guide Epic Development–Time-Constrained Distributed Team Work in an Undergraduate Higher Education Course on Informatics and Society. *Journal of Educational Multimedia and Hypermedia*, 29(3), 227–245.
- Healy, K., & Moody, J. (2014). Data visualization in sociology. *Annual Review of Sociology*, 40, 105–128.
- Heer, J., & Boyd, D. (2005). Vizster: Visualizing online social networks. *IEEE Symposium on Information Visualization, 2005. INFOVIS 2005.*, 32–39.
- Hevner, A., & Chatterjee, S. (2010). *Design Research in Information Systems* (Vol. 22). Springer US. <https://doi.org/10.1007/978-1-4419-5653-8>
- Hogg, M. A. (2016). Social identity theory. In *Understanding peace and conflict through social identity theory: Contemporary global perspectives* (pp. 3–17). Springer.

- Huber, M., & Froehlich, D. E. (2020). *Analyzing group interactions*. Routledge.
- Huizinga, J. (2014). *Homo ludens* 86. Routledge.
- Hulshult, A. (2019). Using eight agile practices in an online course. *Quality. Journal of Higher Education Theory and Practice*.
- Hüther, G. (2016). *Mit Freude lernen—ein Leben lang: Weshalb wir ein neues Verständnis vom Lernen brauchen. Sieben Thesen zu einem erweiterten Lernbegriff und eine Auswahl von Beiträgen zur Untermauerung*. Vandenhoeck & Ruprecht.
- Kennedy, H., & Hill, R. L. (2018). The feeling of numbers: Emotions in everyday engagements with data and their visualisation. *Sociology*, 52(4), 830–848.
- Kirk, A. (2019). *Data visualisation: A handbook for data driven design* (Second edition). SAGE.
- Komus, A. (2013). Agile Methoden in der Praxis—Studie zur Anwendung und Zufriedenheit. *HMD Praxis Der Wirtschaftsinformatik*, 50, 91. <https://doi.org/10.1007/BF03340799>
- Kotrba, V., & Miarka, R. (2019). *Agile Teams lösungsfokussiert coachen*. dpunkt. verlag.
- Kotter, J. P. (2014). *Accelerate: Building strategic agility for a faster-moving world*. Harvard Business Review Press.
- Krivitsky, A. (2017). *lego4scrum—One of the most interactive ways of introducing Agile thinking and Scrum framework* (3rd edn). Leanpub.
- Kriz, J. (2013). Person-Centered Approach and Systems Theory. In J. H. D. Cornelius-White, R. Motschnig-Pitrik, & M. Lux (Eds), *Interdisciplinary Handbook of the Person-Centered Approach* (pp. 261–275). Springer New York. https://doi.org/10.1007/978-1-4614-7141-7_18
- Kriz, J., & Simon, F. B. (2019). *Der Streit ums Nadelöhr: Körper, Psyche, Soziales, Kultur. Wohin schauen systemische Berater?* (M. Ohler, Ed.; Erste Auflage). Carl-Auer Verlag GmbH.
- Kuckartz, U. (2018). *Qualitative Inhaltsanalyse: Methoden, Praxis, Computerunterstützung* (4. Auflage). Beltz Juventa.
- Lackner, H., Spielhofer, T., & Bareck, K. (2019). Organisationen spielerisch verändern. *Austrian Management Review*, 9, 57–67.
- Landherr, A., Friedl, B., & Heidemann, J. (2010). A Critical Review of Centrality Measures in Social Networks. *Business & Information Systems Engineering*, 2(6), 371–385. <https://doi.org/10.1007/s12599-010-0127-3>
- Larman, C., & Vodde, B. (2016). *Large-scale scrum: More with LeSS*. Addison-Wesley Professional.
- Larsen, K. S. (1974). Conformity in the Asch experiment. *The Journal of Social Psychology*, 94(2), 303–304.
- Lazar, J. (2017). *Research methods in human computer interaction* (2nd edition). Elsevier.
- Lim, V. K., & Teo, T. S. (2009). Mind your E-manners: Impact of cyber incivility on employees' work attitude and behavior. *Information & Management*, 46(8), 419–425.
- Luhmann, N. (1978). *Organisation und Entscheidung: 227. Sitzung am 18. Januar 1978 in Düsseldorf*. <http://link.springer.com/openurl?genre=book&isbn=978-3-531-07232-6>
- Magana, A. J., Seah, Y. Y., & Thomas, P. (2018). Fostering cooperative learning with Scrum in a semi-capstone systems analysis and design course. *Journal of Information Systems Education*, 29(2), 75–92.
- Majeed, S., Uzair, M., Qamar, U., & Farooq, A. (2020). Social Network Analysis Visualization Tools: A Comparative Review. *2020 IEEE 23rd International Multitopic Conference (INMIC)*, 1–6. <https://doi.org/10.1109/INMIC50486.2020.9318162>

- Martin, L., Hauret, L., & Fuhrer, C. (2022). Digitally transformed home office impacts on job satisfaction, job stress and job productivity. COVID-19 findings. *Plos One*, 17(3), e0265131.
- Martí-Parreño, J., Méndez-Ibáñez, E., & Alonso-Arroyo, A. (2016). The use of gamification in education: A bibliometric and text mining analysis. *Journal of Computer Assisted Learning*, 32(6), 663–676.
- Massey, A. P. (2003). Because Time Matters: Temporal Coordination in Global Virtual Project Teams. *Journal of Management Information Systems*, 19(4), 129–155. <https://doi.org/10.1080/07421222.2003.11045742>
- Mayring, P. (1994). Qualitative Inhaltsanalyse. In *Texte verstehen: Konzepte, Methoden, Werkzeuge*. UVK Univ.-Verl. Konstanz.
- Mayring, P. (2022). *Qualitative content analysis: A step-by-step guide* (1st edition.). SAGE Publications Ltd. <https://app.talis.com/textbooks/9781529766738>
- McLaren, B. M., Scheuer, O., & Mikšátko, J. (2010). Supporting Collaborative Learning and E-Discussions Using Artificial Intelligence Techniques. *International Journal of Artificial Intelligence in Education*, 20(1), 1–46. <https://doi.org/10.3233/JAI-2010-0001>
- Mersch, D. (2006). Wittgensteins Bilddenken. *Deutsche Zeitschrift Für Philosophie*, 54(6), 925–942.
- Midway, S. R. (2020). Principles of Effective Data Visualization. *Patterns*, 1(9), 100141. <https://doi.org/10.1016/j.patter.2020.100141>
- Moore, J. M., Small, M., & Yan, G. (2021). Inclusivity enhances robustness and efficiency of social networks. *Physica A: Statistical Mechanics and Its Applications*, 563, 125490.
- Moreno, J. L. (1941). *Foundations of sociometry: An introduction*. Beacon House. <https://ubdata.univie.ac.at/AC11980345>
- Moreno, J. L. (1996). *Die Grundlagen der Soziometrie: Wege zur Neuordnung der Gesellschaft* (Unveränderter Nachdr. der 3. Aufl.). Leske + Budrich.
- Mulki, J. P., & Jaramillo, F. (2011). Workplace isolation: Salespeople and supervisors in USA. *The International Journal of Human Resource Management*, 22(04), 902–923.
- Muszyńska, K., & Swacha, J. (2021, September). *Periodic Indicators for Graphical Monitoring of Team Communication in Information System Development Projects*. 29th International Conference on Information Systems Development, Valencia, Spain.
- Nam, C. W. (2014). The effects of trust and constructive controversy on student achievement and attitude in online cooperative learning environments. *Computers in Human Behavior*, 37, 237–248.
- Noguera, I., Guerrero-Roldán, A.-E., & Masó, R. (2018). Collaborative agile learning in online environments: Strategies for improving team regulation and project management. *Computers & Education*, 116, 110–129.
- Opsahl, T., Agneessens, F., & Skvoretz, J. (2010). Node centrality in weighted networks: Generalizing degree and shortest paths. *Social Networks*, 32(3), 245–251. <https://doi.org/10.1016/j.socnet.2010.03.006>
- Österle, H., Becker, J., Frank, U., Hess, T., Karagiannis, D., Krcmar, H., Loos, P., Mertens, P., Oberweis, A., & Sinz, E. J. (2011). Memorandum on design-oriented information systems research. *European Journal of Information Systems*, 20(1), 7–10. <https://doi.org/10.1057/ejis.2010.55>
- Palincsar, A. S. (1998). Social constructivist perspectives on teaching and learning. *Annual Review of Psychology*, 49(1), 345–375.
- Pariser, E. (2011). *The filter bubble: How the new personalized web is changing what we read and how we think*. Penguin.
- Park, S., & Kim, S. (2018). Patterns among 754 gamification cases: Content analysis for gamification development. *JMIR Serious Games*, 6(4), e11336.

- Pavlović, J. (2021). Team Coaching Psychology: Toward an Integration of Constructivist Approaches. *Journal of Constructivist Psychology*, 34(4), 450–462.
- Peñarroja, V., Orengo, V., Zornoza, A., & Hernández, A. (2013). The effects of virtuality level on task-related collaborative behaviors: The mediating role of team trust. *Computers in Human Behavior*, 29(3), 967–974.
- Pentland, A. (2014). *Social physics: How good ideas spread-the lessons from a new science*. Penguin.
- Polt, W., & Rimser, M. (2006). *Aufstellungen mit dem systembrett: Interventionen für coaching, beratung und therapie*. Ökotopia Verlag.
- Rapanta, C., Maina, M., Lotz, N., & Bacchelli, A. (2013). Team design communication patterns in e-learning design and development. *Educational Technology Research and Development*, 61, 581–605.
- Robelski, S., Keller, H., Harth, V., & Mache, S. (2019). Coworking Spaces: The Better Home Office? A Psychosocial and Health-Related Perspective on an Emerging Work Environment. *International Journal of Environmental Research and Public Health*, 16(13). <https://doi.org/10.3390/ijerph16132379>
- Robertson, B. J. (2015). *Holocracy. The New Management System for a Rapidly Changing World*. New York.
- Rousseau, R., & Zhang, L. (2008). Betweenness centrality and Q-measures in directed valued networks. *Scientometrics*, 75(3), 575–590. <https://doi.org/10.1007/s11192-007-1772-2>
- Rowe, J., Mott, B., McQuiggan, S., Robison, J., Lee, S., & Lester, J. (2009). Crystal island: A narrative-centered learning environment for eighth grade microbiology. *Workshop on Intelligent Educational Games at the 14th International Conference on Artificial Intelligence in Education, Brighton, UK*, 11–20.
- Samrose, S., Zhao, R., White, J., Li, V., Nova, L., Lu, Y., Ali, M. R., & Hoque, M. E. (2018). Coco: Collaboration coach for understanding team dynamics during video conferencing. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies*, 1(4), 1–24.
- Schein, E. H. (1980). *Organizational psychology* (3. ed.). Prentice-Hall Internat. <https://ubdata.univie.ac.at/AC02091480>
- Schein, E. H. (2010). *Organizational culture and leadership* (Vol. 2). John Wiley & Sons.
- Schein, E. H. (2015). Organizational psychology then and now: Some observations. *Annu. Rev. Organ. Psychol. Organ. Behav.*, 2(1), 1–19.
- Schindler, R. (1957). Grundprinzipien der Psychodynamik in der Gruppe. *Psyche*, 11(5), 308–314.
- Schindler, R. (1973). Das Verhältnis von Soziometrie und Rangordnungsdynamik. *Heigl-Evers, A.(Hg.): Gruppendynamik. Göttingen: Vandenhoeck & Ruprecht*.
- Schlippe, A. von. (2010). *Familientherapie im Überblick: Basiskonzepte, Formen, Anwendungsmöglichkeiten* (12., überarb. Neuaufl.). Junfermann.
- Schmid, L., Wörn, J., Hank, K., Sawatzki, B., & Walper, S. (2021). Changes in employment and relationship satisfaction in times of the COVID-19 pandemic: Evidence from the German family Panel. *European Societies*, 23, S758. <https://doi.org/10.1080/14616696.2020.1836385>
- Scott, P., Tomadaki, E., & Quick, K. (2007). The shape of online meetings. *The International Journal of Technology, Knowledge, and Society*, 3(4), 1–16.
- Serçe, F. C., Swigger, K., Alpaslan, F. N., Brazile, R., Dafoulas, G., & Lopez, V. (2011). Online collaboration: Collaborative behavior patterns and factors affecting globally distributed team performance. *Computers in Human Behavior*, 27(1), 490–503. <https://doi.org/10.1016/j.chb.2010.09.017>

- Shea, P., Hayes, S., Vickers, J., Gozza-Cohen, M., Uzuner, S., Mehta, R., Valchova, A., & Rangan, P. (2010). A re-examination of the community of inquiry framework: Social network and content analysis. *The Internet and Higher Education*, 13(1), 10–21. <https://doi.org/10.1016/j.iheduc.2009.11.002>
- Simon, F. B. (2021). *Einführung in die systemische Organisationstheorie*. Carl-Auer Verlag.
- Sodeur, W. (2019). Bavelas (1950): Communication Patterns in Task-Oriented Groups. In B. Holzer & C. Stegbauer (Eds), *Schlüsselwerke der Netzwerkforschung* (pp. 35–38). Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-21742-6_8
- Sparrer, I. (2009). *Systemische Strukturaufstellungen: Theorie und Praxis* (2., überarb. Aufl.). Carl-Auer-Verl.
- Stadler, C. (Ed.). (2013). *Soziometrie: Messung, Darstellung, Analyse und Intervention in sozialen Beziehungen*. Springer Fachmedien Wiesbaden. <https://doi.org/10.1007/978-3-531-18981-9>
- Stober, D. R., & Grant, A. M. (2010). *Evidence based coaching handbook: Putting best practices to work for your clients*. John Wiley & Sons.
- Sun, A., & Chen, X. (2016). Online education and its effective practice: A research review. *Journal of Information Technology Education: Research*, 15, 157–190.
- Tashakkori, A., & Teddlie, C. (2003). Issues and dilemmas in teaching research methods courses in social and behavioural sciences: US perspective. *International Journal of Social Research Methodology*, 6, 77. <https://doi.org/10.1080/13645570305055>
- Taylor, H., Fieldman, G., & Lahlou, S. (2005). The impact of a threatening e-mail reprimand on the recipient's blood pressure. *Journal of Managerial Psychology*, 20(1), 43–50.
- Thomas, L., & Harri-Augstein, S. (2001). Conversational science and advanced learning technologies (ALT): Tools for conversational pedagogy. *Kybernetes*, 30(7/8), 921–954. <https://doi.org/10.1108/EUM0000000005917>
- Tomm, K. (1988). Interventive Interviewing: Part III. Intending to Ask Lineal, Circular, Strategic, or Reflexive Questions? *Family Process*, 27(1), 1–15. <https://doi.org/10.1111/j.1545-5300.1988.00001.x>
- Tomm, K. (Ed.). (2014). *Patterns in interpersonal interactions: Inviting relational understandings for therapeutic change*. Routledge.
- Tufte, E., & Graves-Morris, P. (2014). The visual display of quantitative information.; 1983. *Diagrammatik-Reader. Grundlegende Texte Aus Theorie Und Geschichte*. Berlin: De Gruyter, 219–230.
- Venable, J., Pries-Heje, J., & Baskerville, R. (2016). FEDS: A Framework for Evaluation in Design Science Research. *European Journal of Information Systems*, 25(1), 77–89. <https://doi.org/10.1057/ejis.2014.36>
- Ward, L. F. (1892). *Sociocracy*.
- Wasserman, S., & Faust, K. (1994). Social Network Analysis: Methods and Applications. In *Social network analysis: Methods and applications* (Vol. 8). Cambridge University Press.
- Watzlawick, P., Bavelas, J. B., & Jackson, D. D. (2011). *Pragmatics of Human Communication: A Study of Interactional Patterns, Pathologies and Paradoxes*. W. W. Norton. <https://books.google.at/books?id=YcBUAgAAQBAJ>
- Williams, B., & Hummelbrunner, R. (2010). *Systems concepts in action: A practitioner's toolkit*. Stanford University Press.
- Wittgenstein, L. (2010). *Philosophical investigations*. John Wiley & Sons.
- Wittgenstein, L. (2014). *Tractatus logico philosophicus* (7. Aufl.). Suhrkamp.

- Woolley, A. W., Chabris, C. F., Pentland, A., Hashmi, N., & Malone, T. W. (2010). Evidence for a Collective Intelligence Factor in the Performance of Human Groups. *Science*, 330(6004), 686–688. <https://doi.org/10.1126/science.1193147>
- Yin, R. K. (2018). *Case study research and applications: Design and methods* (Sixth edition). SAGE.
- Zhu, J. (2020). Directly Hit the COVID-19: Research on Online Education under “Suspended Class, Ongoing Learning”. *Proceedings of the 2020 4th International Conference on Education and E-Learning*, 214–219.
- Zou, W., Hu, X., Pan, Z., Li, C., Cai, Y., & Liu, M. (2021). Exploring the relationship between social presence and learners’ prestige in MOOC discussion forums using automated content analysis and social network analysis. *Computers in Human Behavior*, 115, 106582. <https://doi.org/10.1016/j.chb.2020.106582>
- Zumkeller, V. (2010). *Coaching: Grundsätze, Prozessphasen und Techniken*. Cornelsen.

11 Appendix A: Publications

11.1 Paper 1: Developing Teams by Visualizing Their Communication Structures in Online Meetings

This is the published version of the paper by Spielhofer T. & Motschnig R., in *Multimodal Technologies and Interaction*, October 19th, 2023.

This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>). Licensee MDPI, Basel, Switzerland.



Article

Developing Teams by Visualizing Their Communication Structures in Online Meetings

Thomas Spielhofer and Renate Motschnig



<https://doi.org/10.3390/mti7100100>

Article

Developing Teams by Visualizing Their Communication Structures in Online Meetings

Thomas Spielhofer ^{1,*} and Renate Motschnig ² 

¹ Doctoral School Computer Science, University of Vienna, Währinger Straße 29, A-1090 Vienna, Austria

² Faculty of Computer Science, University of Vienna, Währinger Straße 29, A-1090 Vienna, Austria; rene.motschnig@univie.ac.at

* Correspondence: thomas.spielhofer@univie.ac.at; Tel.: +43-699-17600531

Abstract: This research pursues the question of how the computer-generated analysis and visualization of communication can foster collaboration in teams that work together online. The audio data of regular online video meetings of three different teams were analyzed. Structural information regarding their communication was visualized in a communication report, and then, discussed with the teams in so-called digitally supported coaching (DSC) sessions. The aim of the DSC is to improve team collaboration by discerning helpful and less helpful patterns in the teams' communication. This report allows us to recognize individual positions within the teams, as well as communication structures, such as conversational turn taking, that are relevant for group intelligence, as other research has shown. The findings pertaining to the team members during the DSC were gathered via questionnaires. These qualitative data were then matched with the quantitative data derived from the calls, particularly social network analysis (SNA). The SNA was inferred using the average number of interactions between the participants as measured in the calls. The qualitative findings of the teams were then cross-checked with the quantitative analysis. As a result, the assessment of team members' roles was highly coherent with the SNA. Furthermore, all teams managed to derive concrete measures for improving their collaboration based on the reflection in the DSC.

Keywords: online communication; team coaching; visualization



Citation: Spielhofer, T.; Motschnig, R. Developing Teams by Visualizing Their Communication Structures in Online Meetings. *Multimodal Technol. Interact.* **2023**, *7*, 100. <https://doi.org/10.3390/mti7100100>

Academic Editor: Marcelo Worsley

Received: 11 September 2023

Revised: 25 September 2023

Accepted: 9 October 2023

Published: 19 October 2023



Copyright: © 2023 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

1.1. Purpose and Approach of This Research

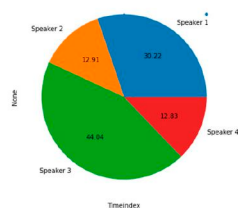
Supporting online collaboration becomes more and more relevant as communication has significantly shifted from personal to virtual meetings in the wake of the COVID-19 pandemic. This has affected professional, educational, and private life. The tool and the method of digitally supported coaching introduced here aims to improve team online collaboration. It does so by analyzing and visualizing patterns of communication, such as participants' interactions as well as the social structure of the team, reflected by the relative positions of team members. This approach is based on the experience that visualizing communication patterns and structures can be helpful in understanding team dynamics, as explored in the field of sociometry [1]. The visualization of social interplay to support learning is also a common concept in some team coaching approaches [2]. The approach presented in this paper provides a seamless and efficient technique of capturing data through extensions of the video conferencing tool Zoom™. The generated set of visualization is integrated into a digitally supported coaching (DSC) scenario. The current paper describes all components of the DSC along with three case studies aimed to validate our approach and envisage its further development.

From the viewpoint of Watzlawick's communication theory, understanding the patterns of communication is key to understanding the underlying social system: "The search for pattern is the basis for all scientific investigation. Where there is pattern there is

significance—this epistemological maxim also holds for the study of human interaction” [3]. From this theoretical perspective, it seems worthwhile to use the possibilities of computer analysis to help detect and visualize patterns in online communication to support the reflection of team collaboration. The approach examined in this analysis seeks to make teams more aware of the unwritten rules of their communication by helping them to discern constructive and less constructive patterns in their communication.

To this avail, the author has developed a tool that analyses recorded online video meetings and visualizes the communication that took place. Once three to four meetings of the same kind with the same team have been visualized and compiled into a communication report, this report is discussed with the team as part of a digitally supported coaching session. The objective of the DSC is for the team to gain insight into their communication patterns and to learn how to conduct their meetings more constructively. Conversational turn taking can be viewed in the interaction and airtime diagrams; the “rhythm” of the conversation, for instance, whether there are long monologues or dense interactions, can be seen in the communication sequence diagrams, as Figure 1 illustrates. Qualitative information gathered right after each meeting provides insight into which meetings participants perceived as more constructive or efficient than others.

Airtime Report
Overall Call
14.3.2022

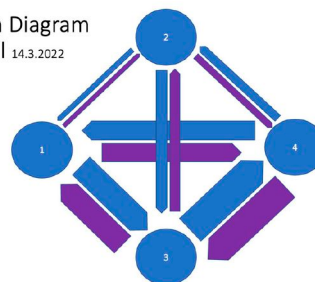


Interaction Diagram
Overall Call 14.3.2022

Shows the number of interactions between participants, e.g. how often B spoke directly after A

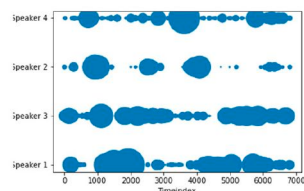
The thicker the line, the higher the number of interactions

In this case
max = 200, min = 27



Communication Sequence, Date 14.3.2022

Each Bubble Represents a speech. The bigger the bubble the longer the speech
y-Axis: Speaker, x-Axis: Timeline



Your responses to the questionnaires

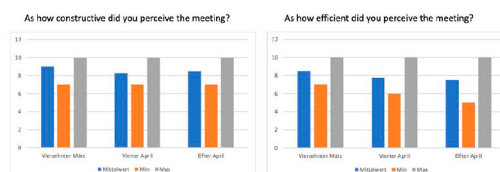


Figure 1. Excerpt from a sample communication report.

As illustrated in Figure 1, the interaction diagram shows the number of interactions between the meeting participants. The interaction data are also used to conduct a social network analysis (SNA) between the players, with each node representing one team member, and the ties between actors representing the interaction between these team members. The thickness of the tie represents the number of interactions. This allows us to compute the centrality metric of each team member. The quantitative data form a basis for cross-checking the internal subjective views of the team members in the DSC, thus providing different views on team communication: model-based quantitative data and the perceptions of the team members.

This research investigates to what extent teams can learn from this approach employing a multiple-case study. The focus is on two aspects of online team collaboration: the roles

and the interaction within teams. Other aspects of communication and team coaching could be pursued using this approach in further research.

1.2. Theoretical Foundation

Watzlawick's communication theory is the foundation for understanding the term communication pattern and its significance for team communication used in this research. Watzlawick uses the game of chess as a simile for human communication [3]. An outside observer, who does not know the game of chess, could deduct the rules by watching a series of games played. Communication, when seen as interaction between players and the inherent lawfulness of this interaction, is defined as a stochastic process in this theory. "Stochastic process refers to the lawfulness inherent of symbols or events", for instance, "the patterns of tonal and orchestral elements by a composer". A stochastic process implies that in each context, some events are more likely to happen than others. In Mozart's piano sonatas, an andante is likely to be followed by an allegro. When a certain team approaches a decision, it might be that many remain silent while there is intense staccato-like interaction by two or three people followed by a certain person having the last word. For the purpose of this research, Watzlawick's concepts are followed in defining communication patterns as the inherent lawfulness of interaction within a certain group. It is a lawfulness that we tend to be oblivious to, as Watzlawick argues: "we are particularly unaware of the rules being followed in successful, and broken in disturbed, communication". It is a lawfulness that can be brought to light by observing the communication of several meetings, as the first proposition of this research states: discerning communication patterns in a team can help the team to improve their communication.

Gregory Bateson introduced the idea of metapatterns, which he called symmetrical and complementary dynamics. A team where members strongly compete would be an example of a symmetrical communication dynamic. An example of a complementary dynamic would be team members taking different roles that complement each other. Bateson argues that either pattern, when taken to the extreme, would lead to the breakdown of the social system: "On the one hand, various sorts of symmetrical rivalry among individuals were observed and it was evident that such rivalrous sequences of interaction could be progressive [i.e., self-reinforcing] and therefore ultimately pathogenic" [4].

Reflecting communication patterns can also be key to improving group intelligence. As empirical research has shown, the equality of conversational turn taking was the largest factor in predicting group intelligence [5]. Group intelligence in this research was defined by the performance groups showed in work-related tasks like brainstorming, judgement, and planning. Patterns of conversational turn taking are a type of communication pattern that can be measured by analyzing the interaction between participants without analyzing the content of what has been spoken.

The team coaching approach followed in the DSC is based on constructivist-systemic coaching. This approach "encourages incremental changes in terms of small steps toward the desired position on a particular topic" in seeking to "facilitate movement toward desired team positions as defined by the team" [6]. Constructivist-systemic coaching has roots in constructivist therapy [7]. One basic assumption of constructivist therapy is that "reality arises from consensual linguistic processes" [8]. In this view, the distinction between what is helpful and what is detrimental to good team communication emerges during the team discussion when reflecting the communication report. This is incorporated in the second research proposition: studying their communication patterns can help team members to learn about their roles and their interactions within a team.

All findings in these team coaching processes are specific to the context of the respective team. This follows another fundamental assumption of De Shazer, that "the meaning of words is determined by how they are used by the various participants within a specific context". De Shazer shows an understanding of language that is rooted in Ludwig Wittgenstein's philosophy as expressed in his later work [9]. Therefore, which communica-

tion patterns are deduced from a communication report and whether they are considered helpful is highly context-specific.

2. Related Work

Extensive work exists on the relevance of communication patterns in therapy and coaching. Here, “questions are formulated to bring forth the ‘patterns that connect’ persons, objects, actions, perceptions, ideas, feelings, events, beliefs, contexts, etc., in recurrent or cybernetic circuits” [10].

Sociograms and the value of visualizing social systems were widely explored by J.L. Moreno [11]. His initial empirical study of a New York School, including the methods employed there, has become a reference for sociometry until today and has been further elaborated on [1].

Samrose and colleagues evaluated ways of analyzing and visualizing online video communication [12]. As early as 2003, Anne Massey analyzed and visualized temporal patterns in global virtual project teams to explore “the nature of team interaction and the role of temporal coordination in asynchronously communicating GVPTs” [13]. In this research, temporal patterns are defined as the flow of interactions over time that influence communicative, decisional, and interpersonal behaviors in teams. Other research has covered the graphical analysis of indicators “which measure the intensity of various aspects of users’ communication activity in periodic manner” [14]. Here, aspects such as variances in the project activity or differences in users’ activity levels were visualized for the identification of various types of team communication issues, for instance, when a “user only asks for information but does not provide any”. Research has supported that in distributed online team work, “synchronous communication encourages social interaction and expressions of different views” [15].

Various pieces of work exist on the use of social network analysis. As in this research, some work used SNA as part of a mixed-method approach. Mixed-method approaches can be defined “as research in which the investigator collects and analyzes data, integrates the findings, and draws inferences using both qualitative and quantitative approaches or methods in a single study or a program of inquiry” [16]. The use of SNA in combination with critical discourse analysis (CDA) in a mixed-method approach was used to explore the social dynamics in a classroom [17]. Here, CDA and SNA were combined to detect the change in informal leadership in a group of pupils in a classroom from one person to another over time. Another mixed-method study was conducted to explore social systems, aimed at discerning so called guanxi circles in Chinese organizations. Guanxi circles are “pseudofamilies in a person’s working life and at work usually develop from ego-centered social networks around one focal person” [18]. A mixed-method approach combining SNA and Natural Language Processing was used to analyze Massive Open Online Courses (MOOCs). [19]. Text obtained from the MOOC was analyzed and mapped to social presence using the theoretical framework of Shea et al. [20], thus creating information regarding the social position of the students. This was then cross-checked with the results of the SNA, particularly regarding the in-degree centrality and the authority score.

Research on sociological phenomena that involved digitally measuring human interactions was carried out by Alex Pentland, who called this branch of research social physics [21]. In his research, Pentland, for instance, found that the “rhythm” of interaction of the highest-performing teams consisted of “many short contributions rather than a few long ones” [21]. Pentland further stated that “in studies of more than two dozens of organizations I have found that interaction patterns typically account for almost half of all the performance variation between high- and low-performing groups” [21].

3. Research Questions and Propositions

This research pursues the following questions for teams that collaborate online through video meetings:

RQ1: What can teams learn about their communication from reflecting upon its visualization in interaction diagrams?

RQ1.1: How well can the individual positions of team members be recognized by the team through this approach?

RQ1.2: How well can the interplay within the team be recognized by the team through this approach?

This research is based on the following propositions:

1. Discerning communication patterns in a team can help the team to improve their communication.
2. Studying a team's communication patterns can help team members to learn about their roles and their interactions within a team.
3. Visualizing patterns is a helpful way to convey them to the team.

4. Methods

4.1. Research Design

This research is designed as a multiple-case study following theoretical replication logic as outlined by Yin [22]: the same research questions are pursued with the same research design for three selected cases. Two of the cases are IT companies of similar size operating in the same geographical region. One organization is a large international company.

Each case is bound by encompassing a specific group in a specific organizational context. The sessions recorded are all part of the same online meeting series serving a specific function for the respective teams, e.g., a weekly jour fixe. The meeting invitees of all cases remained constant in the period observed, the actual participants per meeting varied in some instances due to sick leave or other absences.

To increase the construct validity of the study, each case has two sources of evidence: quantitative and qualitative data.

4.2. Quantitative Data

Quantitative data were obtained through the meeting recordings. The meetings were conducted using the video conferencing tool Zoom™ (<https://zoom.us>, accessed on 30 October 2021, Version 5.7). This tool was chosen as it allowed us to store separate audio files for each participant when recording the meeting. From these audio files, the so-called diarization of each speaker was derived automatically through the software written for this research, including the point in time and length of each time this participant spoke in the meeting. Further (aggregated) data were then automatically calculated by combining the diarization data of all speakers:

1. The “airtime”: the percentage of speaking time each speaker had overall.
2. The number of times each specific speaker spoke after another speaker (interaction).
3. The sequence of speaking events throughout a meeting.

Point 2, the interaction, serves as the basis for the social network analysis. Interaction is regarded as one person speaking after another person. It is based on the assumption that in most cases, the statement of a person represents an “Anschlusskommunikation”—a communication that is connected to what has been said before. This creates a margin of error for communications in which statements are not related to one another and therefore the communication does not represent an interaction. In non-pathological communications, as researched here, we assume that this is the exception, not the rule, and therefore does not interfere with the search for communication patterns.

Based on this interaction diagram, a social network analysis was conducted. “The objective of social network analysis is the description and analysis of relationships between different actors” [17]. In this study an actor is defined as one person within the team. Actors are labeled as $P_1 \dots P_n$. “Actors are connected by ties that are determined, for example, by behavioral or physical interaction” [17]. In this study, one tie represents the number of

times a person spoke after the other in one specific meeting, and t_{11} is the number of times A spoke after B in meeting 1.

A relation differs from a tie as it reflects a social aspect between two actors that is relevant to the entire network. It is “the measurement of different ties in an overall network” [17]. Relations in this study reflect the interaction between two actors over the course of all observed meetings. They are weighted as follows: the higher the number of interactions, the higher the weight of the relation. Accordingly, the relation between P_1 and P_2 is defined as:

$$R_{12} = \frac{\sum_{i=1}^n t_{i1} + t_{i2}}{n}$$

where n is the number of meetings that both P_1 and P_2 attended.

Based on this, the degree centrality of each team member can be calculated. As the social network is constructed using a graph with weighted nodes (with the relation R as described above), the information of the weights can be taken into account when calculating the centrality measure. As a suitable way to compute degree centrality for social networks with weighted nodes, the following definition was chosen [23]:

$$s_i = \sum_{j=1}^m w_{ij}$$

where m is the total number of nodes, w is the weighted adjacency matrix, in which w_{ij} is greater than 0 if node i is connected to node j , and the value represents the weight of the tie.

Various alternate definitions for centrality in social networks with weighted nodes have been proposed. The centrality definition of “the number of nodes that a focal node is connected to, and the average weight to these nodes adjusted by the tuning parameter [23], for instance, takes both the weight of the nodes as well as the number of relations an actor has into account. This can be advantageous when we have a social network with a very uneven number of relations between its actors. However, this comes at a price: this metric requires a parameter alpha to balance the relevance of node weight and the number of relations. This increases the complexity of the metric and requires empirical work to justify which value to use for alpha in what context. Another approach is to view role positions based on the number of incoming ties, seeing a prestigious actor as one to whom many ties are directed [24]. This forms a concept that has been carried on, for instance, to define centrality in asymmetric networks [25]. Other centrality measures cater to complex social networks with subgroups [26].

In the current study, which investigates small social networks, the advantages of more complex metrics do not seem to outweigh their disadvantages. Following the principle of Occam’s razor, it seems prudent to apply the least complex model and increase the complexity of the model as more complex problems (in this case, more complex social networks) are being investigated using this approach.

The quantitative data are also used to create visual representations of the communication in each meeting. This process is supported by the software, with the interaction diagram currently being the only one needing manual composition utilizing the automatically generated data. Together, these visual representations compose a communication report encompassing the following:

1. The airtime, visualized as a pie chart, as illustrated in Figure 1;
2. The number of times each speaker spoke after another speaker, visualized as an interaction diagram;
3. The sequence of speaking events throughout a meeting, visualized as a sequence diagram.

4.3. Qualitative Data

Qualitative input data were collected at a digitally supported coaching (DSC) session. At this event, the team members met to reflect their communication based on the

communication report of their meeting series. The DSC was facilitated by an experienced constructivist-systemic coach.

Upon reflecting on the communication report, the team could exchange different viewpoints on the overall communication structure. Furthermore, everybody could check their own feeling against the real data on how involved they were. Communication patterns could be discerned when viewing the visualization of several meetings side by side. The team members could then ask themselves which of their patterns were helpful and what might be worth changing to attain more constructive communication. This reflection process was structured in the DSC following a uniform agenda.

The DSC followed the same predefined agenda:

1. Introduction.
2. Going through the report (communication visualizations) of one meeting.
3. Team members are asked to reflect on:
 - The whole “image” that they see in the interaction diagram and the communication sequence diagram.
 - Their own communication behavior that they recognize in the visualizations.
 - Their particular communication behavior, and what (if anything) surprised them. Furthermore, they were encouraged to share what they derived from what they saw.
4. Giving an overview of all recorded meetings: airtimes and interaction diagrams.
5. Looking for recurring patterns, following the question “what is typical for our team communication?”.
6. Answering of the questionnaire by all meeting participants.
7. Feedback on the report.
8. Closing.

In point 6 of the DSC, the participants filled out the following questionnaire:

1. What communication patterns did you detect through this report? (things that are typical for your communication)
2. What contributed to constructive communication?
3. What could you as a team change to achieve more constructive communication?
4. What contributed to efficient communication?
5. What could you as a team change to achieve more efficient communication?

The DSC questionnaire was filled out by all DSC participants in cases 1 and 2. In case 3, only the moderator found the time to fill out the questionnaire. This case is nevertheless used in this study as its other data are fully available and provide relevant findings.

These qualitative data reflect what insights were obtained by the participants during the digitally supported coaching. Researching question 1, the results of the questionnaire are used to see what teams can learn about their communication through this team coaching approach. The sentences of the questionnaire served as coding units. They were analyzed through a reflexive thematic analysis as outlined by Braun and Clarke [27]. Codes were formed inductively as recommended by Mayring [28], and recurring themes were identified.

4.4. Mixing the Methods

In this research, qualitative and quantitative data represent two sources of evidence. Each reflects the communication that took place in the meeting series in a different way. The social network analysis represents the metrics that can be inferred from the actual speaking times. The qualitative information obtained from the questionnaires is used to find out what the participants learned from the DSC as defined in research questions 1.1 and 1.2. These data represent the subjective perspectives of the participants: what they see and consider noteworthy in the visualizations of the communication they find in the report after having discussed it with the other team members.

To answer research questions 1.1 and 1.2 the qualitative data were cross-checked with the metrics of the social network analysis (which had not been disclosed in the DSC) to see what similarities and differences the qualitative findings and the quantitative metrics hold. Regarding RQ 1.1, the degree centrality, as a quantitative measure to assess the centrality of a person with the team, was compared with what the team members expressed in the questionnaires. This way, it could be assessed to what extent the insights team members gained regarding their role within the team matched with the SNA. Regarding RQ 1.2, the measure of the weight of relations was compared with the internal view of the team regarding the intensity of their interactions. This way, the results of the qualitative analysis regarding team interactions could be compared with the results of the quantitative analysis.

4.5. Participant Recruitment

The organizations participating in this research were chosen because they had previous contact with the author in his work as organizational consultants or through academic cooperation with the author or the author's colleagues. All organizations who were willing and had resources to participate at that point in time were included in this research. Before starting the research, all members of the participating teams were informed about the research and how the data would be anonymously used for research purposes. They were then asked for their consent to participate under these terms. All members of the three teams agreed.

5. Results

5.1. Case 1

5.1.1. Team and Meeting Series

The team in case 1 consists of four team members, two men and two women. They meet every week for one hour online in their weekly *jour fixe*. The *jour fixe* is of the operative kind, supported by quantitative data as input prepared prior to the meeting. The team is part of a company of around 100 people. Team member P2 could not participate in the DSC; therefore, answers to the questionnaire are only available from P1, P3, and P4.

5.1.2. Analysis of the Roles and Interactions within the Team

The team viewed the communication report, including the airtime and interaction diagrams of four meetings beside one another, as shown in Figure 2. This graphic is specifically designed so that teams can detect patterns in their communication more easily. After the reflection of the communication report, the team members regarded P4 as the person leading the meeting, as the qualitative analysis shown in Table 1 indicates. This is coherent with the social network analysis, where P4 turns out to have the highest degree centrality, as Table 2 shows. One theme of the analysis stated that interaction mainly ran through the meeting leader, and another theme more specifically pointed out that the highest interaction was between P1 and P4. This is coherent with the SNA, where the most intense relation is between P4 and P1, followed by P4 and P2, as Table 3 shows. The participants nonetheless regarded their communication as “balanced and at eye-level”, as the qualitative analysis shows.

The team further reflected on the strong centrality of their leader, when asked what could contribute to achieving more constructive communication. One theme stated that “More interaction between participants apart from P1” would be helpful, and another found that P3 could be more involved. This reflects the current situation, where P3 has the lowest airtime and the lowest degree centrality, as the SNA shows.

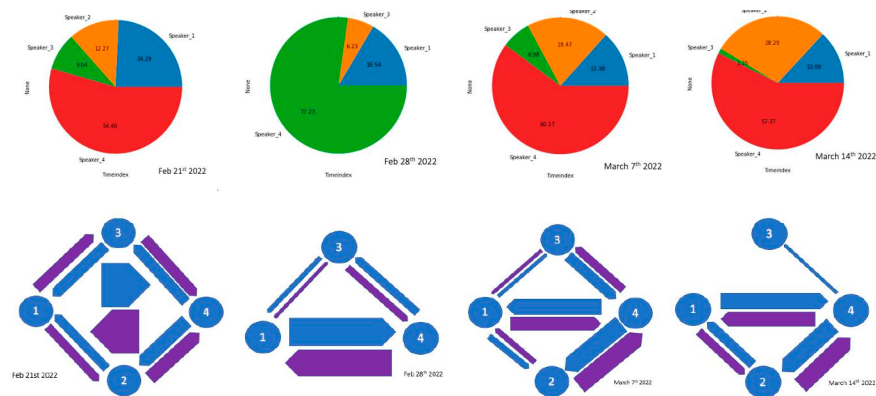


Figure 2. Airtimes and interaction diagrams of four meetings in case 1.

Table 1. Results of the thematic analysis of the three questions in the questionnaire in case 1.

What Communication Patterns Did You Detect through This Report?	What Contributed to Constructive Communication?	What Could You as a Team Change to Achieve More Constructive Communication?
P4 leads the meeting	Clear roles	Pay attention to topics other than one's own
Meetings are structured	Communication was balanced and at eye-level	Give the team more time to add topics
Interaction mainly takes place between P1 and P4	Everybody was involved (even if the parts have a different weighting)	P3 could be more involved in the meeting
Interaction mainly runs through P4	P4 dispatching to all others	More interaction between participants apart from P1
I hold back in the meeting		

Table 2. Degree centralities in case 1.

Team Member	Degree Centrality
P1	255.58
P2	169.67
P3	90.33
P4	330.75

Table 3. Relations and their weights in case 1.

Relation	Weight of Relation
P1–P2	52.33
P1–P3	33.75
P1–P4	169.50
P2–P3	6.33
P2–P4	111.00
P3–P4	50.25

5.2. Case 2

5.2.1. Team and Meeting Series

As in case 1, the team in case 2 consists of four team members, two men and two women. They meet every week for one hour online in their weekly jour fixe. The jour fixe is of a more general kind; input is sometimes provided, but is not a meeting prerequisite. The team is part of a company of around 40 people.

5.2.2. Analysis of the Roles and Interactions within the Team

The team, after viewing and reflecting the interactions as shown in Figure 3, identified P3 as moderator and the person with the highest number of interactions, as the result of the qualitative analysis shows (see Table 4). This is coherent with the SNA indicating that P3 has the highest centrality measure, as shown in Table 5.

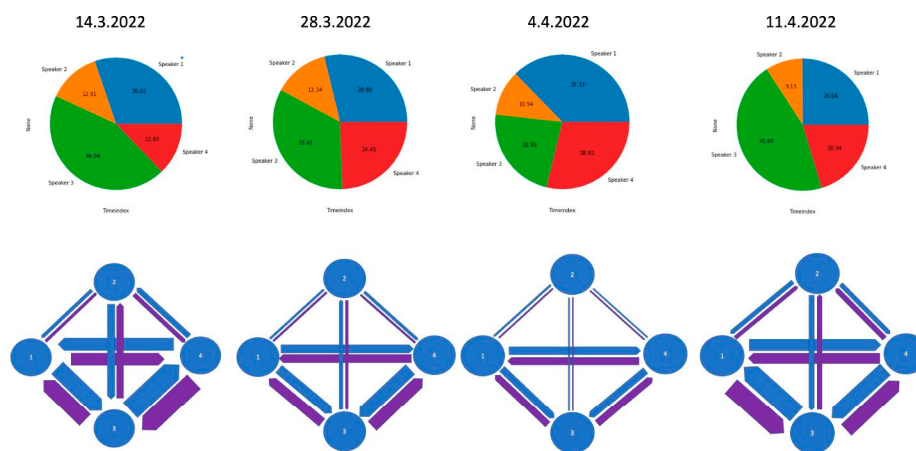


Figure 3. Airtimes and interaction diagrams of four meetings in Case 2.

Table 4. Result of the qualitative analysis of the questionnaires in the digitally supported coaching session in case 2.

What Communication Patterns Did You Detect through This Report?	What Contributed to Constructive Communication?	What Could You as a Team Change to Achieve more Constructive Communication?
P2 constantly has the fewest, but very balanced and constant, interactions with others	Culture of open and honest communication	Increase meeting efficiency
P3 is visibly the moderator, having the highest airtime and interactions with others	Moderator, who involves everybody	Involve P2 more
The communication reflects who has which task intersections with whom	The meeting frame	Ask good questions
P1 acts like a hub between different people with different areas of responsibility	The regularity of the meeting	More fact orientation
Patterns of the meetings become visible	Good meeting focus	
Intensity of interactions between P1 and P4 remain constant across the meetings	Fact orientation	
Partial interruptions in communication		
Occasional long discussions		

Table 5. Degree centralities in case 2.

Team Member	Degree Centrality
P1	462.75
P2	184.75
P3	564.00
P4	492.50

P2 was recognized as the person with the lowest speaking time, but the team also recognized that she continuously had quite balanced interactions with all other participants throughout the meetings. Both impressions are supported by the quantitative data: P2 has only 43% of the average number of interactions within the team but keeps her interaction on a similar level to all team members, with a coefficient of variation of 22%. Accordingly, P2 has very similar weights in her relationships with all the other participants, as Table 6 shows.

Table 6. Relations and their weights in case 2.

Relation	Weight of Relation
P1–P2	48.75
P1–P3	235.25
P1–P4	178.75
P2–P3	75.50
P2–P4	6.50
P3–P4	253.25

P1 is regarded as the “communication hub”, having a high relative airtime and a high number of interactions with all other participants. This corresponds with the average actual airtime of 30.34% of the spoken time within these four meetings. The number of interactions between P1 and the other team members is second only to the moderator.

The team also recognized that their communication behavior reflects “who has which task intersections with whom”. In their reflection, the team appreciates a lot of its qualities, such as the communication culture and the value of the moderator. Suggestions for room for improvement are both on an organizational level (increasing meeting efficiency) as well as on a relationship level (involve P2 more).

5.3. Case 3

5.3.1. Team and Meeting Series

Case 3 covers a team of middle management, their supervisor, who is part of the senior management, and the moderator. Altogether, they are 19 people: 10 women (including the moderator) and 9 men. However, not all of them can attend their weekly jour fixe of one hour. The average number of attendees was 11 in the three meetings observed. Their jour fixe is structured into phases featuring a check-in, information and decision phases, and a check-out. The meeting is supported by a tool in which all issues to be discussed are entered prior to the meeting. The management team is part of a large international corporation.

5.3.2. Analysis of the Roles and Interactions within the Team

Here, only the perspective of the moderator could be captured in the qualitative analysis. She clearly discerns several patterns in the communication of this team: She states that “the boss always had the highest airtime”, as Table 7 shows. And indeed, the supervisor (P10), who attends this regular meeting with his employees, always had between 37 and 47 percent of the airtime, as Figure 4 illustrates. Secondly, she recognizes, that the

highest interaction is between the moderator and the supervisor. Both of these statements are supported by the quantitative data: the highest number of interactions is between the boss and the moderator (with the exception of meeting three, where P7 co-moderated with P1), as Table 8 shows. Thirdly, she discerns, that communication ran mainly through the moderator. This is also supported by the quantitative data; the moderator has the highest centrality, as Table 8 shows. In fact, there were hardly any interactions other than with the moderator. Only the supervisor occasionally had interactions with other persons. All of the top 10 weighted relations involved either the moderator or the supervisor.

Table 7. Result of the qualitative analysis of the questionnaires in the digitally supported coaching session in case 3.

What Communication Patterns Did You Detect through This Report?	What Contributed to Constructive Communication?	What Could You as a Team Change to Achieve more Constructive Communication?
Airtimes were quite unbalanced	Humor	As moderator, taking more care to have balanced airtimes
Boss always had the highest airtime	Check-in	Better including people who came late to the meeting
Late-comers had low interactions	Strict time management	
Strong interaction between moderator and boss	Tool support to manage variety of tasks	
Communication ran mainly through moderator		

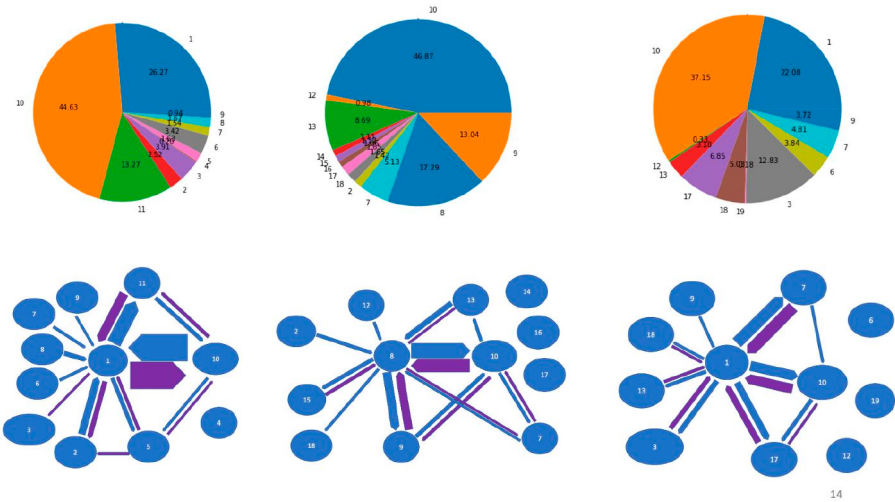


Figure 4. Airtimes and interaction diagrams of four meetings in Case 3.

Remarkably, all three aspects of their communication appear when the moderation role is taken by another person; in the second meeting, P8, a stand-in for P1 (who was on vacation at that time), served as moderator. And the airtime of the boss was again by far the highest (47% in a meeting with 12 participants); the interaction was again highest between the moderator and supervisor, and the interactions from all participants were mostly with the supervisor and the moderator. This pattern becomes quite visible when viewing the interaction diagram illustrated in Figure 4. It resembles a star topology of a network with

the moderator serving as the hub. This is also reflected by the degree centralities: by far the highest centrality was held by the moderator (P1), as Table 9 shows. She had a degree centrality of 400, with the median of all centralities being 55. According to the SNA, by far her strongest relation was with the supervisor, being more than 50% stronger than the second strongest relation. (As there were 19 persons in these calls with 171 relations, only the 10 relations with the highest values are shown in Table 8.)

Table 8. Strongest 10 relations and their weights in case 3.

Relation	Weight of Relation
P1–P10	102
P1–P11	66
P8–P10	45
P1–P7	37
P1–P2	34
P1–P17	33
P8–P9	23
P1–P8	22
P8–P13	22
P8–P15	21

Table 9. Degree centralities in case 3.

Team Member	Degree Centrality
P1	400
P2	85
P3	55
P4	9
P5	51
P6	25
P7	78
P8	207
P9	64
P10	252
P11	119
P12	42
P13	74
P14	17
P15	33
P16	15
P17	63
P18	44
P19	7

Through the communication report, the moderator also recognized that people who were late to the meeting and missed the check-in were hardly involved. The moderator con-

cluded that she would strive to ensure more balanced involvement of meeting participants and to better integrate those who are late.

6. Discussion

6.1. General Observations Regarding the Cases

Cases 1 and 2 are comparable insofar as they both feature a team of four persons having a weekly *jour fixe* meeting of one hour. However, their communication could hardly be more different. As the data derived using the tool shows, team 1 has one dominant speaker with more than 50% speaking time in every meeting. Speaking time in team 2 is more balanced, with an overall number of interactions seven times as high as in team 1. In light of the empirical research on group intelligence [5], it may be asked what the effect of this kind of communication is on leveraging the potential of team 1 compared to team 2. This, however, must consider the nature of the meeting. Group intelligence as measured by Wolley et al. focused on brainstorming, judgement, and planning tasks. There might be meetings where a one-to-many communication pattern, as in team 1, is useful.

The third case is special, as it also shows that communication patterns in a team can prevail even when the moderation role switches from one person to another, as occurred in meeting 2, with the supervisor having most of the airtime and a moderator through whom the communication runs. The most interaction occurs between moderator and supervisor, and together, they capture around two thirds of the airtime of each meeting. If others in the meeting speak, this occurs almost exclusively as a result of the interaction with this duo—a pattern that became overt through the communication report. The communication report of case 3 also unmasked that in this meeting series, several people hardly participated at all. This could be used to raise follow-up questions: What are these people contributing to these meetings? Is this in line with the purpose of this meeting series, and if not, what could be changed?

6.2. Findings Addressing the Research Questions

Regarding RQ1.1, “How well can the individual positions of team members be recognized by the team through this approach?”, the teams reliably found the leader of the meeting, and identified people who were central to their communication and those less involved in cases 1 and 2. Here, the results of the questionnaires matched the analysis of the SNA. In case 3, the dominant role of the boss in these meetings and how the moderator supported that communication pattern became visible.

Regarding RQ1.2, “How well can the interplay within the team be recognized by the team through this approach?”, the team in case 1 quickly discerned that most interaction was carried out through their leader (P4), with a strong interplay between him and P1. P3 was seen as less involved, and she considered herself as “careful to interfere”. All of this is coherent with the centrality measures and the weight of the relations. In case 2, the team also recognized that there was a leader and a second person who increased the interaction. However, the interaction was more balanced and much higher than in case 1 (by 600%). The team also found that one person was less involved in the interaction, but her interactions with others were balanced. Again, this is coherent with the weights of the relations.

Regarding the overarching RQ1, “What can teams learn about their communication from a mixed-method approach using social network analysis and qualitative methods?”, the qualitative data show that the discussion of the communication report led to meaningful discussions in the DSC and to concrete ideas about how to make their communication more constructive in all three cases. The findings for improvements ranged from social aspects, like bringing a certain person more into play, striving for more balanced airtimes as a moderator, and better including late-comers into the meeting, to practical issues like preparing an agenda prior to the meeting or focusing on topics that are relevant to all participants.

This is an initial indication that team members were able to accurately assess their roles and discern patterns in their interactions and learn from the DSC, as proposed by this research.

7. Limitations

A limitation of this study is that it only covered three cases. Another limitation might be that all teams functioned in a Western-dominated culture. Furthermore, the reports were analyzed by one person only, possibly being biased. This potential bias was minimized by discussing the qualitative findings with other professionals in the field.

8. Conclusions

In all three cases examined in this research, the visualizations “spoke” to team members, as they became more aware of any regularities in their communication behavior. They identified aspects of their roles and their interactions based on the communication report that were coherent with the quantitative data. Furthermore, in each case, discussing the communication report helped the teams to discern which response pattern turned out to be constructive and which were less so. This indicates that—under proper conditions—the digitally supported coaching approach as described in this work can contribute to improving the collaboration of teams working together online.

It appears that having a structural view on communication can be a good basis for reflecting the collaboration within a team. The current study provides initial evidence on the applicability and promotive effects of the developed tools, visualization, and digitally supported coaching session structure. Further research across different application contexts and cultures is needed to confirm or relativize the findings presented in this study.

In this research, the focus was on roles and interactions within teams. Other areas of research could focus on how a DSC can lead to more efficient meetings or can help to resolve tensions within a team. Patterns indicating or leading to innovative processes or products might be explored by adapting the approach presented in this paper. Other lines of research could use the quantitative data generated by the tool presented here to explore predictors for group intelligence in teams working together online. A further path would be to use the visualizations and SNA metrics generated by the tool to monitor the integration of new members in a team working together online over time. Moreover, it could be investigated whether predictive machine learning models could be trained to indicate upcoming turning points in conversations, such as conflicts, based on the diarization data generated using this tool. This would follow the assumption that the “rhythm” of a conversation changes in a certain way before a turning point in a conversation occurs.

Author Contributions: Conceptualization, T.S.; methodology, T.S. and R.M.; software, T.S.; validation, T.S. and R.M.; formal analysis, T.S.; investigation, T.S.; resources, T.S. and R.M.; data curation, T.S.; writing—original draft preparation, T.S.; writing—review and editing, R.M.; visualization, T.S.; supervision, R.M.; project administration, T.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: This research was conducted in accordance with the ethical guidelines of the University of Vienna and the Vienna Manifesto on Digital Humanism.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data of the recorded calls have not been made publicly available due to privacy restrictions.

Acknowledgments: The authors wish to thank the University of Vienna for the opportunity to conduct this research. Special thanks go to the participating teams for their time and openness to support this research, to David Haselberger and Peter Krummenacher for their most valuable inputs, and to Martin Kahr and Michael Hartinger for their support in developing the tool. Open Access Funding by the University of Vienna.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Stadler, C. (Ed.) *Soziometrie: Messung, Darstellung, Analyse und Intervention in Sozialen Beziehungen*; Springer: Wiesbaden, Germany, 2013. [CrossRef]
2. von Schlippe, A. *Familientherapie im Überblick: Basiskonzepte, Formen, Anwendungsmöglichkeiten*; 12., überarb. Neuaufl.; Fachbuch Familientherapie; Junfermann: Paderborn, Germany, 2010.
3. Watzlawick, P.; Bavelas, J.B.; Jackson, D.D. *Pragmatics of Human Communication: A Study of Interactional Patterns, Pathologies and Paradoxes*; W. W. Norton: New York, NY, USA, 2011; Available online: <https://books.google.at/books?id=YcBUAgAAQBAJ> (accessed on 20 April 2021).
4. Bateson, G. Cultural Problems Posed by a Study of Schizophrenic Process. In *Symposium on Schizophrenia, an Integrated Approach*; Auerback, A., Ed.; Ronald Press: New York, NY, USA, 1959.
5. Woolley, A.W.; Chabris, C.F.; Pentland, A.; Hashmi, N.; Malone, T.W. Evidence for a Collective Intelligence Factor in the Performance of Human Groups. *Science* **2010**, *330*, 686–688. [CrossRef] [PubMed]
6. Pavlović, J. Team Coaching Psychology: Toward an Integration of Constructivist Approaches. *J. Constr. Psychol.* **2019**, *34*, 450–462. [CrossRef]
7. De Shazer, S. *Clues: Investigating Solutions in Brief Therapy*; WW Norton & Co.: New York, NY, USA, 1988.
8. De Shazer, S. *Putting Difference to Work*, 1st ed.; Norton: New York, NY, USA, 1991.
9. Wittgenstein, L.; Anscombe, G.E.M. *Philosophical Investigations*; Basic Blackw: London, UK, 1953.
10. Tomm, K. Interventive Interviewing: Part III. Intending to Ask Lineal, Circular, Strategic, or Reflexive Questions? *Fam. Process* **1988**, *27*, 1–15. [CrossRef] [PubMed]
11. Moreno, J.L. *Foundations of Sociometry: An Introduction*; Sociometry Monographs/4; Beacon House: New York, NY, USA, 1941; Available online: <https://ubdata.univie.ac.at/AC11980345> (accessed on 30 June 2023).
12. Samrose, S.; Zhao, R.; White, J.; Li, V.; Nova, L.; Lu, Y.; Ali, M.R.; Hoque, M.E. Coco: Collaboration Coach for Understanding Team Dynamics during Video Conferencing. *Proc. ACM Interact. Mob. Wearable Ubiquitous Technol.* **2018**, *1*, 1–24. [CrossRef]
13. Massey, A.P.; Montoya-Weiss, M.M.; Hung, Y.-T. Because Time Matters: Temporal Coordination in Global Virtual Project Teams. *J. Manag. Inf. Syst.* **2003**, *19*, 129–155. [CrossRef]
14. Muszyńska, K.; Swacha, J. Periodic Indicators for Graphical Monitoring of Team Communication. In Proceedings of the 29th Information System Development Projects, Valencia, Spain, 8–10 September 2021.
15. Serge, F.C.; Swigger, K.; Alpaslan, F.N.; Brazile, R.; Dafoulas, G.; Lopez, V. Online collaboration: Collaborative behavior patterns and factors affecting globally distributed team performance. *Comput. Hum. Behav.* **2011**, *27*, 490–503. [CrossRef]
16. Bickman, L.; Debra, R. *The SAGE Handbook of Applied Social Research Methods*; SAGE Publications, Inc.: Thousand Oaks, CA, USA, 2009. [CrossRef]
17. Huber, M.; Dominik, E.F. *Analyzing Group Interactions*; Routledge: New York, NY, USA, 2020.
18. Fu, X.; Luo, J.-D.; Margarete, B. *Social Network Analysis: Interdisciplinary Approaches and Case Studies*; CRC Press: Boca Raton, FL, USA, 2017. [CrossRef]
19. Zou, W.; Hu, X.; Pan, Z.; Li, C.; Cai, Y.; Liu, M. Exploring the relationship between social presence and learners' prestige in MOOC discussion forums using automated content analysis and social network analysis. *Comput. Hum. Behav.* **2020**, *115*, 106582. [CrossRef]
20. Shea, P.; Hayes, S.; Vickers, J.; Gozza-Cohen, M.; Uzuner, S.; Mehta, R.; Valchova, A.; Rangan, P. A re-examination of the community of inquiry framework: Social network and content analysis. *Internet High. Educ.* **2010**, *13*, 10–21. [CrossRef]
21. Pentland, A. *Social Physics: How Good Ideas Spread-the Lessons from a New Science*; Penguin: New York, NY, USA, 2014.
22. Yin, R.K. *Case Study Research and Applications: Design and Methods*, 6th ed.; SAGE: Los Angeles, CA, USA, 2018.
23. Opsahl, T.; Agneessens, F.; Skvoretz, J. Node centrality in weighted networks: Generalizing degree and shortest paths. *Soc. Netw.* **2010**, *32*, 245–251. [CrossRef]
24. Wasserman, S.; Faust, K. *Social Network Analysis: Methods and Applications. Social Network Analysis: Methods and Applications; Structural Analysis in the Social Sciences*; Cambridge University Press: Cambridge, UK, 1994; Volume 8.
25. Bonacich, P.; Lloyd, P. Eigenvector-like measures of centrality for asymmetric relations. *Soc. Netw.* **2001**, *23*, 191–201. [CrossRef]
26. Rousseau, R.; Zhang, L. Betweenness centrality and Q-measures in directed valued networks. *Scientometrics* **2008**, *75*, 575–590. [CrossRef]
27. Braun, V.; Clarke, V. Thematic Analysis: A Practical Guide. *Qmip Bull.* **2022**, *1*, 46–50. [CrossRef]
28. Mayring, P. *Qualitative Content Analysis: A Step-by-Step Guide*, 1st ed.; SAGE Publications Ltd.: Thousand Oaks, CA, USA, 2022; Available online: <https://app.talis.com/textbooks/9781529766738> (accessed on 12 July 2023).

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

11.2 Paper 2: Digitally supported coaching and its application to developing self-organizing teams

This is the published version of the paper by Spielhofer T. & Motschnig R., published in *Human-Intelligent Systems Integration*, November 8th, 2024.

This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.



Digitally supported coaching and its application to developing self-organizing teams

Thomas Spielhofer¹ · Renate Motschnig²

Received: 16 February 2024 / Accepted: 25 October 2024
© The Author(s) 2024

Abstract

Digital communication has become mainstream in professional as well as in educational collaboration. While it reduces the richness of non-verbal interaction, it also opened up novel, accessible, and low-cost opportunities for professional as well as personal development. This paper presents the findings of applying the framework called digitally supported coaching (DSC) to a self-organized team that partly collaborates via online video conferences. The DSC features a software tool that analyzes and visualizes communication data of several meetings and a team coaching process to use these visualizations for team development. This allows teams to discern helpful and less helpful patterns in their communication and to learn from that. While DSC has already been evaluated in multiple case studies in different contexts, this study explores the use of DSC for a self-organized team for the first time. Applying a mixed method approach, the team communication was analyzed from the subjective perspectives of the team members as well as based on the quantitative data of the meetings and the social network analysis (SNA) derived from it. Compared to hierarchical teams, the results show a much higher variety in team centralities and significant differences in the way meetings were led. Learnings by the team in this case included insights regarding their roleplay, the way they moderated meetings, and their development towards more constructive communication over time. The case indicates the potentials of DCS for self-organized teams particularly regarding their flexibility in taking on roles, tasks, and reflective practice.

Keywords Team coaching · Self-organizing teams · Video conferencing · Online collaboration · Digitally supported coaching

1 Introduction

Through the rise of agile methods, self-organized teams have become a more widespread and appreciated way of collaboration (Komus 2013). The agile manifesto states “The best architectures, requirements, and designs emerge from self-organizing teams” (<https://agilemanifesto.org/>). Self-organization implies a new way of leadership, as there is no hierarchical leader who tells others how work is distributed,

how solutions for problems are found, or how decisions are made.

A special form of self-organizing teams occurs when collaboration is partly or entirely conducted via the Internet. We refer to such teams as self-organized online teams (SOOTs). Virtual collaboration is particularly challenging for SOOTs, as self-organized collaboration in an agile understanding was originally associated with onsite settings. Only then does the density of individual interaction occur that is at the core of the agile principles. The agile manifesto rates “individuals and interactions over process and tools” and further states that “the most efficient and effective method of conveying information to and within a development team is face-to-face conversation” (<https://agilemanifesto.org/>). By 2001, when the agile manifesto was created, face-to-face conversation typically referred to onsite communication. Therefore, collaboration in an online setting can be particularly challenging for teams that self-organize. In light of this challenge,

✉ Thomas Spielhofer
thomas.spielhofer@univie.ac.at
Renate Motschnig
renate.motschnig@univie.ac.at

¹ Doctoral School Computer Science, University of Vienna,
Währinger Straße 29, 1090 Vienna, Austria

² Faculty of Computer Science, University of Vienna,
Währinger Straße 29, 1090 Vienna, Austria

one may ask how self-organization can be realized in virtual communication settings.

The purpose of this case study is to initially assess the potential of analyzing and visualizing the data generated by SOOTs in online meetings to support the learning process regarding their team collaboration. To this avail, a framework called digitally supported coaching (DSC) is used, an approach that has previously been evaluated in business and learning contexts (Spielhofer and Motschnig 2023; Spielhofer and Haselberger 2023). This framework uses the audio tracks generated in online video calls to visualize their interaction in so-called communication reports. The communication report is then reflected by the team in a coaching session moderated by a professional coach.

A communication report is composed of:

1. The “airtime”: the percentage of speaking time each speaker had overall
2. The sequence of speaking events throughout a meeting
3. The number of times each specific speaker spoke after another speaker (interaction)

Figure 1 shows the communication report for one meeting. The pie chart on the left-hand side depicts the “airtime,” i.e., the share of the overall speaking time, each participant had. The communication sequence in the middle uses one bubble for every point in time (x-axis) a particular participant (y-axis) spoke. The size of the bubbles depicts the speaking time of the respective participant. Thus, the communication sequence reflects the “rhythm” of the conversation, whether, for instance, it is a dense staccato-like interaction of short contributions or a series of long monologues. It can be interesting to reflect on this “conversation rhythm” to assess how well this communication pattern is able to stimulate creativity (Pentland 2014). Moreover, for moderators, the “conversation rhythm” can serve to reflect their communication behavior: is it for instance a series of short interventions stimulating or regulating dialogue of others, or is it rather a mix of moderation and own (longer)

contributions on the content level? The latter would result in far larger bubbles than the former on the communication sequence chart. The interaction diagram on the right-hand side shows how many times one person spoke after another person. It can be argued that in a non-pathological conversation this represents interactions between persons (Spielhofer and Motschnig 2023). It is also the basis to conduct a social network analysis (SNA) that would provide additional relevant information. The interaction diagram reflects the communication structure showing aspects such as the strength of the relations between team members or the reciprocity of relationships. It further provides insight on individual team positions by providing metrics to calculate the centrality of team members.

These reports are designed to help teams to discern their communication patterns in online calls and ask themselves which of these patterns are helpful and what patterns they might want to change. A communication pattern in this understanding is a stochastic concept based on Watzlawick’s communication theory (Watzlawick et al. 2011) referring to recurring interactions among human beings that encompass, among other interactions, the way teams make decisions, integrate new team members, or deal with resistance and criticism. To recognize recurring communication structures, reports of several meetings, typically three to five, are inspected and reflected in a DSC session.

1.1 Related work

The idea of learning among self-organizing teams and how to foster it has already been examined in the 1970s (Harri-Augstein and Thomas 2008; Thomas and Harri-Augstein, 2001) and has been further elaborated since (Coombs and Smith 1998). Various practices for coaching self-organized teams were established in the agile community over the past decades (Adkins 2010; Kotrba and Miarka 2019). The so-called Container-Differences-Exchange model (CDE) provides a theoretical framework for understanding the dynamics of self-organized teams (Eoyang 2012).

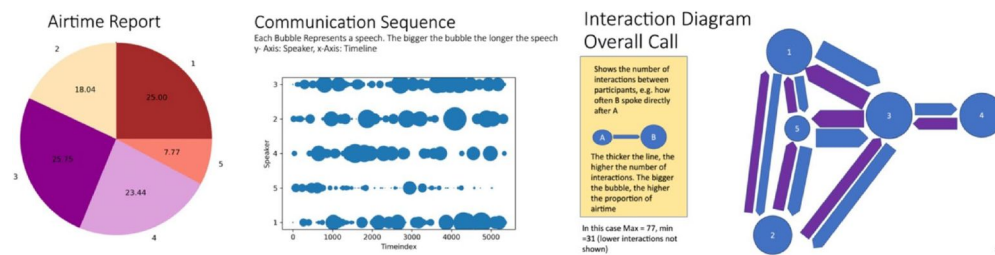


Fig. 1 Communication report of one meeting

It provides a fundament to understand how self-organized teams can be led and coached from a systemic point of view.

An approach to “automate the identification of salient contributions and patterns in student e-discussions” in self-organized discussions among students (McLaren et al. 2010) used a machine learning model to classify and tag the content of discussion. This served (among other things) to identify particularly salient contributions by students. Communication patterns in asynchronous online communication have been researched (Massey 2003). Furthermore, Muszyńska and Swacha (2021) analyzed structural aspects of online communication focusing on the reciprocity of interaction.

Several commercial solutions exist that automatically analyze video online communication to provide insights for the meeting participants and their leaders: Microsoft’s online meeting solution MS Teams for instance features a Speaker Coach (<https://teams.microsoft.com/>). This solution mainly uses content analysis to provide recommendations for meeting participants. Recommendations could for instance include to use a more inclusive language. Cogito (<https://cogitocorp.com>), a spinoff of the MIT MediaLab, states on its website that it combines the analysis of various aspects of communication to detect emotional intelligence and other relevant factors that determine meeting success and employee satisfaction. This is used to provide recommendations to call center agents to help them in their communication with customers. Due to the confidential nature of these proprietary technologies, no publications on their design could be found in our research.

Using SNA and qualitative methods in mixed methods to understand group dynamics is less widely explored. SNA was used in connection with critical discourse to explore the social dynamics in a classroom (Huber and Froehlich 2020). Chinese organizations were analyzed using a mixed method approach, in which an SNA was derived from the formal organization and compared with the informal organization derived from personal interviews (Fu et al. 2017).

Analyzing interactions with the help of continuously gathered quantitative data to gain social insights is the aim of the so-called social physics. Its founder, Alex Pentland, came to the conclusion that “in studies of more than two dozens of organizations I have found that interaction patterns typically account for almost half of all the performance variation between high- and low-performing groups” (Pentland 2014). Two independent large research projects found that the variance of the so-called conversational turn-taking, the indicator of how many times someone speaks within a meeting, is inversely proportional to group intelligence (Woolley et al. 2010; Duhigg 2016). Group intelligence in both research projects was measured in terms of team performance at certain given tasks like estimation, decision-making, or finding solutions to problems.

Several ways of visualizing online communication have been developed and examined in the past. One research studied the effect of visualizing individual turn-taking and emotional reactions (Samrose et al. 2018). The effect of visualizing the sequence of communication has already been analyzed in 2007 using the so-called FlashMeeting™ videoconferencing system. This application features, among other things, a “linear visualization of the event, in which the horizontal bars represent one turn of the named user” (Scott et al. 2007). Another tool, called MeetCues, provides interactive features for the users, for instance for “tagging points during the meeting with a like/clarify reaction” (Aseniero et al. 2020). It uses this input to create a visualization of the meeting communication as an interactive timeline that enables users to see how the meeting’s mood changes over time. In this interactive approach, the purpose of the tool is to change the course of the meeting as it happens. By allowing the users to give input that is then visualized, the users are having a reciprocal interaction with one another and the tool during their online meetings.

The theoretical foundation of DSC and a multiple case study showing the potential of applying it in a business context have been reported (Spielhofer and Motschnig 2023). Another case study examined the potential benefits of applying DSC in an educational context. Here two university student groups engaged in controversial discussions in online video conferences. The aim was to find out what additional learnings these two student groups could gain through DSC after having reflected their communication in a moderated retrospective featuring external observers beforehand (Spielhofer and Haselberger 2023). In both studies, relevant learnings occurred both on an individual level, such as communication behavior or level of participation, and a structural level, such as the balance of conversational turn-taking or the influence of a moderator on the whole group.

1.2 Research questions

While DSC has been studied in various contexts, its value for SOOTs has not yet been investigated. The novelty of this study lies in understanding the crucial social dynamics in SOOTs and how they can be further developed with the help of DSC. Due to the large degree of organizational flexibility and freedom in SOOTs, it is assumed that DSC has the potential to offer useful, easy-to-follow hints for improving communication in SOOTs, in particular. Furthermore, the communication report can be used to compare differences in the communication structures of hierarchical and non-hierarchical teams. Therefore, this research addresses the following questions:

- 1.1. What can SOOTs learn through the reflection of their communication structure during a DSC?

- 1.1. What can SOOTs learn about their roles within a team with the help of DSC?
- 1.2. What can SOOTs learn about their moderation with the help of DSC?

2 Methods

This research is designed as a case study as described by Yin (2018). The case is bound by encompassing a specific meeting series of a specific team: the regular online coordination meetings a core team of a non-profit organization had. One meeting in 2021 and three meetings in 2023 recorded within 8 weeks were made available by the team for this research. Each of these coordination meetings was set to 1 h. The meeting invitees changed between 2021 and 2023, as the participants of the core team changed. Out of the original eight team members (6 female, 2 male) in 2021, five remained in the core team (4 females, 1 male) while three left to serve in other parts of the organization.

This team was selected, as the first author had previously worked with it as a team coach and the team was open to try out a new method. The research started after all team members were informed about the research and had given their written consent for their anonymized data to be used.

The DSC team coaching session was done in two parts: First, the team was shown the visualizations of the meetings in year 2023, to enable the reflection of their current teamwork. In a second step, the visualizations of the meeting in year 2021 were shown, to allow the team members to discern the development of the communication over a longer span of time and in different team compositions.

A mixed method approach was employed to increase the construct validity of the study. Two sources of evidence were used: quantitative data derived from the analysis of the audio data and qualitative data derived from questionnaires the team members answered at the end of the DSC.

The following questions were asked in the questionnaire:

- What did you particularly notice on the communication report?
- What did you notice about your roles?
- What did you notice about the moderation of your meetings?
- What changes have you noticed in your interactions in the online meetings between 2021 and 2023?
- In your opinion, what has contributed to constructive communication in your online meetings?
- What could lead to even more constructive collaboration?

A reflexive thematic analysis of the answers to the questionnaire, as outlined by Braun and Clarke (Braun and Clarke 2022), was conducted to identify common themes

in their findings. Braun and Clarke postulate that the finding of good quality codes and themes “result from dual processes of: (a) immersion and depth of engagement; and (b) giving the developing analysis some distance” (Braun and Clarke 2022). To achieve both immersion and distance seems as paradoxical as accurate. It reflects the need for closeness of the researcher to the social system to discern its core patterns while maintaining the necessary distance to understand it from a new perspective. Embracing this idea, the first author of this paper has coached the team prior to this research and listened to the audio tracks of the meetings to immerse into the group dynamics. He then took some time before elaborating the codes and themes to regain a more distanced perspective. The underlying codes were formed inductively as recommended by Mayring (Mayring 2022). The initial themes were derived by clustering these codes. The result was then reviewed and reflected with a fellow researcher. In this reflection, some underlying assumptions of the researcher about what was relevant in the communication became overt and were discussed. Based on this reflection, the themes were refined, and the final theme names were chosen.

The qualitative data reflect the subjective insights of the participants as expressed in their answers to the questionnaire. The quantitative data reflect the actual “airtimes,” communication sequences, and interactions of the team members in the recorded meetings. It is composed of two steps: First, the audio tracks are used to generate the so-called diarization lists for all meeting participants. One such diarization list holds the point in time and length every time the respective meeting participant spoke. The combined diarization lists of all meeting participants are then used to visualize the team communication. The social network inferred through the interaction was then analyzed and the weight of the relations and the centralities of team members in the meetings were calculated.

The qualitative and quantitative data are then compared to identify commonalities in both views on communication.

3 Results

3.1 Part 1, the meetings in 2023

The themes derived from the qualitative analysis are listed in Table 1. Each of the column headlines represents one question asked in the questionnaire. Underneath, the themes deducted from the answers are listed. Following RQ1, insights of the team regarding their communication structure comprised the distribution of airtime in the meetings and how this varied between meetings. Changes in the balance of speaking times between the 2021 and 2023 meetings were also noticed. Furthermore, the variance in interactions

Table 1 Results of the qualitative analysis

What did you particularly notice on the communication report?	What did you notice about your roles?	What did you notice about moderation of your meetings?	What changes have you noticed in your interactions in the online meetings between 2021 and 2023?	In your opinion, what has contributed to constructive communication in your online meetings?	What could lead to even more constructive collaboration?
P1 and P3 continuously take large shares of the meeting time. The amount of speaking time also reflects the dominance in the project High variance of speaking times and interactions across meetings	P1 talks a lot	By whom and how meetings are moderated changes	Much more balanced speaking times	Respectful listening	Meet at times when people can focus on the meeting
	P3 talks a lot Moderation role changes as reflected in the communication report P2 has individual competence, otherwise keeps low profile P5 speaks when she can, contributions may be on the meta-level	Moderation role is not clearly defined	More constructive communication	Give the floor to hot topics	Rotate the moderation
			Only those who want to contribute are at the meeting	Smaller group	Define moderation more clearly
			P2 automatically took on the role of moderator in 2021 but not in 2023	Better understanding of roles	

when looking at all meetings was mentioned by the team: “High variance of speaking times and interactions across meetings.”

The airtime diagrams of the three meetings in 2023 are illustrated in Fig. 2. Each of the pie charts shows the relative speaking times of meeting participants 1 to 5 for one meeting. While the airtime of all other participants varied significantly, P1 and P3 together constantly took half of the airtime in all three meetings. Table 2 shows the airtime of all team members and their mean and variance across the recorded meetings. The sum of the airtimes of P1 and P3 ranged in the small span of 48.61 to 50.75% in all three meetings. The variance in airtime of P1 and P3 was only at 0.09 and 0.47, respectively, while the variance of the others was significantly higher, ranging from 10.81 to 56.01. In other words, P1 and P3 always had a constant share of the meeting airtime, even though the topics of the meetings were different. This was partly acknowledged in the DSC: “P1 and P3 continuously take large share of the meeting time,” as the qualitative analysis shows (Table 1). One theme provided an interpretation of this data: “The amount of speaking time also reflects the dominance in the project.” This suggests that, in reflecting on the communication report, the team recognized aspects of their role as asked for in RQ1.1. In particular, they seemed to be interested in the speaking time of team members and whether they remained in balance with each other.

The interaction diagrams of the three meetings in 2023 are shown in Fig. 3. The structure varies with each meeting,

Table 2 Airtimes (in percent) and their variances of the meetings in 2023

	P1	P2	P3	P4	P5
Meeting 1	25	18.04	25.75	23.44	7.77
Meeting 2	24.96	9.07	25.69	23.16	17.13
Meeting 3	24.34	27.4	24.27	16.33	7.66
Mean	24.77	18.17	25.24	20.98	10.85
Variance	0.09	56.01	0.47	10.81	19.70

and there is no single person serving as the central communication hub in every meeting. Instead, there is “high variance of speaking times and interactions across meetings” as the participants reflected (see Table 1). In the view of RQ1.1, this indicates that the team reflection concluded that there is no person that continuously dominates the discussion in the team.

Figure 4 shows that the centralities of the participants varied from meeting to meeting. No single person continuously held the position of the most central person in the three meetings according to this SNA metric. Instead, the position of highest centrality within the team was one time assumed by person 3, then person 5, and finally person 2. This might correspond with the observations of the team that “moderation role changes as reflected in communication report” and “by whom and how meetings are moderated changes” (see Table 1), showing the teams’ findings about their team moderation in the DSC, as was the focus of RQ1.2. Another

Airtime distribution of three meetings

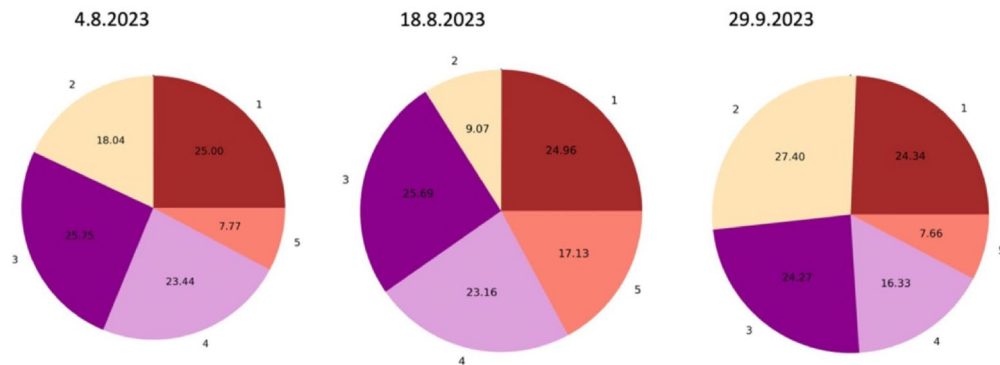
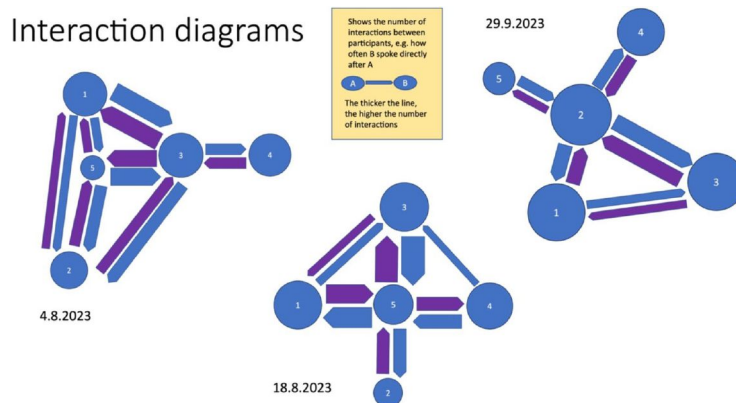
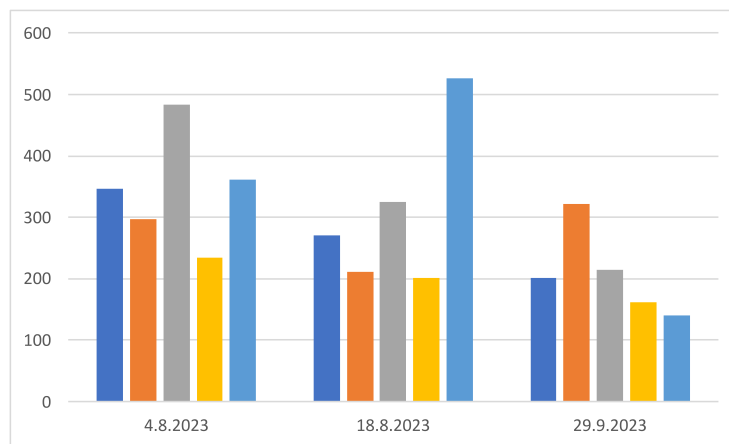


Fig. 2 The airtime diagrams of the three meetings in 2023

Fig. 3 The interaction diagrams of the meetings in 2023**Fig. 4** The centralities of the five participants (from left to right) in the three meetings

aspect in the social network of the team becomes overt when looking at the interaction diagrams of the three meetings: Everyone interacts with everyone else sooner or later, except for participants 1 and 4, who hardly interacted in any of these meetings (the graphs do not show interactions below 14 to keep them easy to read). However, this aspect was not mentioned by the team in the questionnaire after the DSC.

3.2 Part 2, comparison of 2021 and 2023

There was only data from one meeting in 2021 available for this research. However, as it is remarkably different from the 2023 meetings, the communication diagrams from this meeting were shown to the team so that they could draw their conclusions. The airtime was even less balanced than in the 2023 meetings, as Fig. 5 shows. There was one speaker who spoke

43% of the time, whereby two others were below 2%. This was noted by the team members in their reflection. When asked about the changes over time, they noted “much more balanced speaking times” in 2023 compared to 2021 as Table 1 shows.

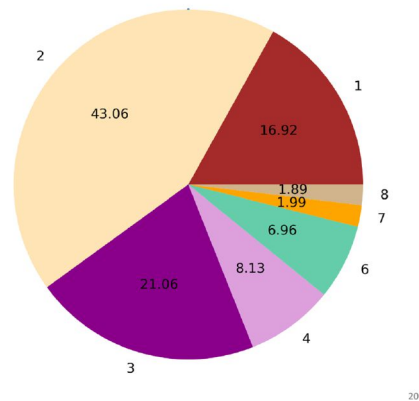
This is also reflected by the interaction diagrams (see Fig. 6). The meeting in 2021 shows participant 2 as the central communication hub through which most of the communication ran. On the other hand, the two participants with low airtime had hardly any interactions with anybody in the meeting.

4 Discussion

Regarding RQ1.1 “What can SOOTs learn about their roles within a team with the help of DSC,” this case shows significant differences compared to the cases of hierarchically

Fig. 5 The airtime report of the meeting in 2021

Airtime Report Overall Call Date 12.10.2021



Interaction diagrams

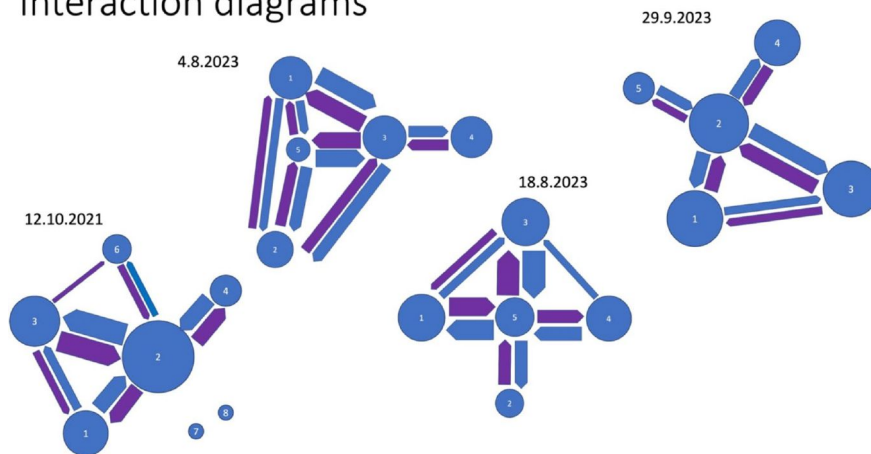


Fig. 6 The interaction diagrams of the meeting in 2021 and the three meetings in 2023

led teams examined in previous research. Looking at the quantitative data for indicators of the team positions, the pattern of the team seems to be that there is no leadership pattern: the centralities of the team members vary significantly from meeting to meeting, as Fig. 4 clearly shows. In this respect, this case of a self-organized team differs fundamentally from the three cases examined in hierarchical organizations (Spielhofer and Motschnig 2023). There, all hierarchically led teams continuously showed the highest centralities for leaders and moderators throughout all meetings. The various interaction diagrams of hierarchical teams also showed a pattern: the same persons serving as a kind of

communication hub in the center of the team in all meetings. No such recurring structure can be observed in the interaction diagrams of this self-organized team. If we consider centrality in social network analysis as a measure of the team position, we may come to the hypothesis that positions in this self-organized team are not as fixed as in hierarchically led teams.

However, some continuity in the roleplay was identified in the DSC. The team noticed the remarkably constant air-times of participants 1 and 3 across the meetings in 2023. As one theme stated, “P1 and P3 continuously take large share of meeting time” (see Table 1). This is coherent with the

quantitative data, which shows that P1 and P3 always have quite precisely 25% of the airtime in all 2023 meetings (see Table 2). This is remarkable given that the three meetings had different agendas and it is unlikely that both P1 and P3 had the same amount to contribute regardless of the topics. This gives rise to seek hypotheses for the balance between their airtimes on a social level, for instance in group dynamics. We could for instance assume that the “amount of speaking time also reflects the dominance in the project,” as one theme in the team reflection did (see Table 1). Following this hypothesis, Raul Schindler’s team ranking model (Schindler 1973) can be used to understand the balance of airtime of two players as a leadership dynamic. Accordingly, P1 and P3 would hold or strive for an alpha role, each of them seeking to balance the participation of the other in order to achieve equal presence in the team. Another hypothesis could be derived from a systemic viewpoint, considering P1 and P3 as representatives of different functions or value areas within the team. The belief polarities model for instance states that there are three different value areas in any team: Bhakti, representing compassion, trust, and social competence; Jnana, representing knowledge, insight, and search for truth, and Karma representing order, structure, and the ability to act (Sparrer 2009). As the Hindu names of the three value domains indicate, this model has emerged from a socio-cultural view of organizations and teams, postulating that this triad of value domains occurs in most societies and, consequently, in the social systems within those societies. Following this model, competition and tension between team members could reflect a tension of the different value domains they represent. In their reflection in the DSC, the team in this case study further noticed the strong presence of P1 and P3 and drew assumptions on their position in the team as well as differentiated assessments of the roles of P2 and P5.

Regarding RQ1.2, “what SOOTs can learn about their moderation with the help of DSC,” the team noticed that both “by whom and how meetings are moderated changes” (see Table 1). As a conclusion of the DSC, team members would find it helpful to define the moderation more clearly. A development of the team moderation can also be observed over time. The team members noted that “P2 automatically took on role of moderator in 2021 but not in 2023” (see Table 1). As the airtime and interaction diagrams show, the way moderation was conducted in all three meetings was very different in 2023 compared to 2021. They were moderated in a way that allowed a more balanced involvement of all participants. This stark difference in the communication balance between 2021 and 2023 was also expressed in other answers to the questionnaire, finding “much more balanced speaking times” in 2023 (see Table 1). This is corroborated by the difference in airtimes, as Figs. 2 and 5 show, and the interactions as illustrated in Fig. 6. In the 2021 meeting, two

participants were hardly actively participating in the discussion and in the decision-making. This is remarkable, given that this is the core team of an organization, which has the purpose to make day-to-day decisions to keep the organization going. Reflecting this, the team stated that in 2023 “only those who want to contribute are at the meeting.” This is consistent with the interaction diagrams, as the core team reduced to five participants had a much more even level of airtime and interaction in 2023 (see Fig. 6). This conclusion should be treated with caution though, as it is drawn from data of only one meeting in 2021.

Regarding RQ1 “What can SOOTs learn through the reflection of their communication structure during a DSC?”, it could be summarized, that in this case study, learnings occurred regarding the roles within the team, the meeting moderation, and the changes of communication over time.

4.1 Limitations

A limitation of this study is that it only covered one case and can therefore only be seen as a basis to form hypotheses regarding the potential outcome of applying the DSC to SOOTs. The authors also need to share that the whole research took place in a western-dominated culture, and we would be excited about broadening our horizon by exploring a culturally more diverse setting and its effects.

5 Conclusions

This case shows the potential for self-organized teams (SOOTs) to identify and learn about certain aspects in their communication under the right circumstances. One such aspect is team positions and their interaction, which can be well illustrated by the interaction diagram and further supported by quantitative indicators of the SNA. The DSC also proved a fruitful ground to reflect the meeting moderation. The communication report enabled the team to discern how much the moderation role varied, both by whom and how it was done. Examples for improvement included the following: to “define moderation more clearly” and to “rotate the moderation” (see Table 1). These themes formed the responses to the question of what could lead to more constructive collaboration.

When looking at the change of communication over time, the DSC and the communication report can serve as confirmation of the development course a team has chosen. In this case, the team found “much more balanced speaking times” and “more constructive communication” in 2023 compared to 2021 (see Fig. 1). In a team coaching setting, this can be used as positive reinforcement to identify and strengthen the resources that led to the change. It can also be used to

identify and curb undesirable tendencies if the report shows otherwise.

On reflection, the visual representation of the communication structure of SOOTs has the added value of explaining a snapshot of the self-organized, real constellation of a team at certain phases of a project. Unlike hierarchically organized teams with pre-defined roles, SOOTs members can use the visualizations to determine their desired structure, so that members can optimally contribute to the goals they have set for themselves in each phase of their project. Conversely, DSC is seen as a framework that is particularly well suited to SOOTs.

Summarizing, this case shows that the DSC can be a valuable, lightweight tool for any self-organized team that partly or wholly communicates through video conferences. Embedded in an appropriately designed team coaching process, the communication report can complement the internal view of team members with a structural view of their communication. A combination that can lead to new insights—insights that can make a difference to the team, as this case shows.

In future work, the current approach could be applied to culturally more diverse team settings. It could also be extended to learn about other aspects of teamwork. One possibility would be to extend the DSC to include contextual information about the cultural backgrounds and language skills of team members, thus supporting studies that aim to determine how people from different backgrounds are integrated into teams. If this approach is applied to many teams within an organization, it could be used to learn about and improve the inclusiveness of the organizational culture. Another research path would be to examine the dynamics of cross-functional teams. The social network analysis part of the DSC could for instance help to find out more about the relationships between software developers and testers in a cross-functional software development team.

Acknowledgements The authors wish to thank the University of Vienna for the opportunity to conduct this research. Special thanks go to the participating team members for their time and openness to support this research.

Funding Open access funding provided by University of Vienna. This research received no external funding.

Data Availability Data of the recorded calls have not been made publicly available due to privacy restrictions.

Declarations

Informed consent Informed consent was obtained from all subjects involved in the study.

Conflict of interest The authors declare no competing interests.

Institutional review board statement This research was conducted in accordance with the ethical guidelines of the University of Vienna and the Vienna Manifesto on Digital Humanism.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

References

- Adkins L (2010) Coaching agile teams: a companion for ScrumMasters, agile coaches, and project managers in transition. Addison-Wesley, Boston
- Aseniero BA, Constantinides M, Joglekar S, Zhou K, Quercia D (2020) 2020 IEEE Visualization Conference - short papers: VIS 2020 : proceedings : virtual event, 25–30 October 2020. IEEE VGTC : IEEE Computer Society, Conference Publishing Services
- Braun V, Clarke V (2022) Thematic analysis: A practical guide (1st edn.). SAGE Publications Ltd, Thousand Oaks
- Coombs SJ, Smith ID (1998) Designing a self-organized conversational learning environment. *Educ Technol* 38(3):17–28
- Duhigg C (2016) What Google learned from its quest to build the perfect team. *N Y times Mag* 26(2016):2016
- Eoyang GH (2012) Human systems dynamics: toward a computational model. 634–637. <https://doi.org/10.1063/1.4756214>
- Fu X, Jar-Der L, Boos M (2017) Social network analysis: interdisciplinary approaches and case studies. CRC Press. <https://doi.org/10.1201/9781315369594>
- Harri-Augstein S, Thomas L (2008) A conversational framework for self-organised learning: modelling personal meaning for effective action in the world. *Handbook of Conversation Design for Instructional Applications* 2008:308–342
- Huber M, Froehlich DE (2020) Analyzing group interactions. Routledge, London
- Komus A (2013) Agile Methoden in der Praxis—Studie zur Anwendung und Zufriedenheit. *HMD Praxis der Wirtschaftsinformatik* 50:91. <https://doi.org/10.1007/BF03340799>
- Kotrba V, Miarka, R (2019) Agile Teams lösungsfokussiert coachen. dpunkt verlag, Heidelberg
- Massey AP (2003) Because time matters: temporal coordination in global virtual project teams. *J Manag Inf Syst* 19(4):129–155. <https://doi.org/10.1080/07421222.2003.11045742>
- Mayring P (2022) Qualitative content analysis: a step-by-step guide (1st edition.). SAGE Publications Ltd. <https://app.talis.com/textbooks/9781529766738>
- McLaren BM, Scheuer O, Mikšátko J (2010) Supporting collaborative learning and e-discussions using artificial intelligence techniques. *Int J Artif Intell Educ* 20(1):1–46. <https://doi.org/10.3233/JAI-2010-0001>
- Muszyńska K, Swacha J (2021) Periodic indicators for graphical monitoring of team communication in information system development projects. 29th International Conference on Information Systems Development, Valencia, Spain

- Pentland A (2014) Social physics: how good ideas spread-the lessons from a new science. Penguin
- Samrose S, Zhao R, White J, Li V, Nova L, Lu Y, Ali MR, Hoque ME (2018) Coco: collaboration coach for understanding team dynamics during video conferencing. *Proc ACM Interact Mobile Wearable Ubiquitous Technol* 1(4):1–24
- Schindler R (1973) Das Verhältnis von Soziometrie und Rangordnungsdynamik. Heigl-Evers, A.(Hg.): Gruppendynamik. Vandenhoeck & Ruprecht, Göttingen
- Scott P, Tomadakis E, Quick K (2007) The shape of online meetings. *Int J Technol Knowl Soc* 3(4):1–16
- Sparrer I (2009) Systemische strukturaufstellungen: theorie und Praxis (2., überarb. Aufl). Carl-Auer-Verl
- Spielhofer T, Haselberger D (2023) Using digitally supported communication analysis to facilitate constructive discourse in educational Courses. In T. Bastiaens (Ed.), *EdMedia + Innovate Learning 2023* (pp. 44–53). Association for the Advancement of Computing in Education (AACE). <https://www.learntechlib.org/p/222481>
- Spielhofer T, Motschnig R (2023) Developing teams by visualizing their communication structures in online meetings. *Multimodal Technol Interact* 7(10):100. <https://doi.org/10.3390/mti7100100>
- Thomas L, Harri-Augstein S (2001) Conversational science and advanced learning technologies (ALT): tools for conversational pedagogy. *Kybernetes* 30(7/8):921–954. <https://doi.org/10.1108/EUM0000000005917>
- Watzlawick P, Bavelas JB, Jackson DD (2011) Pragmatics of human communication: a study of interactional patterns, pathologies and paradoxes. W. W. Norton. <https://books.google.at/books?id=YcBUAgAAQBAJ>
- Woolley AW, Chabris CF, Pentland A, Hashmi N, Malone TW (2010) Evidence for a collective intelligence factor in the performance of human groups. *Science* 330(6004):686–688. <https://doi.org/10.1126/science.1193147>
- Yin RK (2018) Case study research and applications: design and methods, Sixth edn. SAGE, Newcastle upon Tyne

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

11.3 Paper 3: Using digitally supported communication analysis to facilitate constructive discourse in educational Courses

This is the published version of the conference paper by Spielhofer T. & Haselberger D. submitted to and published by *EdMedia + Innovate Learning 2023*.

© 2023 Association for the Advancement of Computing in Education (AACE). Authorized licensed use limited to: Vienna University Library.

Using digitally supported communication analysis to facilitate constructive discourse in educational courses

Thomas Spielhofer
UniVie Doctoral School Computer Science DoCS
Austria
thomas.spielhofer@univie.ac.at

David Haselberger
University of Vienna
Austria
david.haselberger@univie.ac.at

Abstract: This paper covers the evaluation of a new approach to support students' reflection of their communication in online learning settings. Two groups discussed the controversial subject whether Twitter should allow all messages to be tweeted regardless of the content or whether it should block messages that are potentially fake news. The video meetings of these discussions were recorded with the knowledge and consent of all involved persons. The recordings were analyzed by a software tool developed for this purpose by one of the authors, and the group interactions and the discussion flows were visualized in communication reports. The communication reports were designed to help the groups to discern their communication patterns and to enable them to find out which patterns were helpful for the group discussion. The groups reflected on their discussion in two steps: at first by viewing the video, and a second time by viewing the communication report. Comparing the outcome of the first and second reflection shows that additional insights could be gained in step 2: the individual behavior and how it affected the group discussion, the interaction within the group and whether subgroups had been formed, and what roles had emerged and the value they had for the discussion.

Introduction

In the wake of the Covid pandemic online courses have become a more prevalent means of education, posing new challenges for lecturers and students alike. The available technical infrastructure for online communication can only partly substitute the richness of onsite communication. The lack of personal interaction has heavily hampered the social fabric that connects students with each other and with lecturers. This paper introduces a new approach how constructive discourse between students in online discussions can be supported with a digital tool that analyses and visualizes certain aspects of intra-group communication. The presented approach is based on Watzlawick's communication theory (Watzlawick et al., 2011). According to Watzlawick, communication in a group can be understood through analyzing the interaction between the group members and discerning communication patterns therein: "The search for pattern is the basis for all scientific investigation. Where there is pattern there is significance – this epistemological maxim also holds for the study of human interaction" (Watzlawick et al., 2011).

Our key research assumption is that visualizing and discussing such communication patterns fosters the social learning within a group, which is particularly relevant from a perspective on learning which acknowledges the "interdependence of social and individual processes in the co-construction of knowledge" (Palincsar, 1998). Social learning is particularly important in self-organized learning within a university course where knowledge is gained through learning conversations – an approach that aims to "produce personal conversational scientists, life-long learners, seekers after effective understanding: people prepared to construct their own meanings and then consider, evaluate and make selective use of other-generated knowledge." (Thomas & Harri-Augstein, 2001).

This research aims to evaluate to what extent this assumption holds true in two cases examined. The research questions are:

- RQ1: How can student team communication be facilitated in university online learning contexts by reflecting their communication patterns?
- RQ1.1: How can constructive communication patterns be discerned in controversial online group discussions held via video conferences?
- RQ1.2: how can visualizing intra-group communication help to recognize helpful and less helpful aspects in controversial online group discussions held via video conferences?

In the evaluation presented here, two groups discussed a controversial topic in an online video conference. The discussion topic was: Should Twitter allow all messages to be tweeted regardless of the content or should it block messages that are potentially fake news. During the following on-site meeting, the videos of the discussion were viewed together within the respective groups. Participants and observers reflected on their communication. This intra-group reflections were moderated by the lecturers. Then, the communication reports the lecturers had prepared were presented and discussed within the groups. Comparing the outcome of this second reflection with the result of the first round indicated of what potential value this communication report holds for the learning process of teams.

The video calls were conducted and recorded with the digital conferencing application Zoom (<https://zoom.us>), as this software allows to save separate audio tracks (one per participant). The audio tracks were automatically analyzed with software implemented for research purposes by one of the authors to capture the point in time where each person starts to speak and how long each person speaks. This data was analyzed and visualized forming the communication report (an example is shown in Fig. 1):

- Speaking times are aggregated and the percentage of the overall speaking time each person had is calculated. This is visualized in the so-called “airtime report”.
- The communication sequence is computed, showing who spoke how long at which point in time. The x-axis on the communication sequence diagram represents time, the y-axis has n discrete rows, one for each participant. The size of the bubbles in this chart represents how long a participant spoke then. The airtime is visualized as a pie chart showing the relative speaking time of each participant.
- An interaction diagram is inferred counting the numbers of times person 1 spoke after person 2, based on the assumption that a communication act is typically based on what previously has been spoken (“Anschlusskommunikation”). An assumption that is in line with Watzlawick’s communication theory for non-pathological communications. The interaction diagram follows the idea of the sociogram as introduced by Moreno (Moreno, 1941): It represents the relationship between actors in a group based on their number of interactions. This can be used both to understand the overall structure of the communication and the position of individual members within the group.

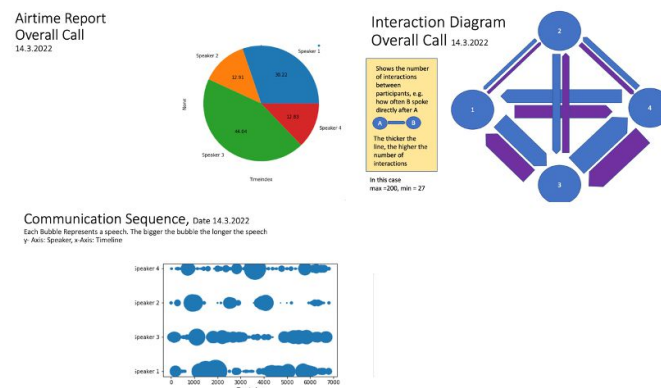


Fig. 1: An example communication report

The communication report was complemented with additional information where applicable.

Related Work

Extensive work has been published on how to design self-organized learning and what the role of the lecturers should be in facilitating the learning process (Coombs & Smith, 1998).

Rapanta et al. (2013) pursued the questions of how to find suitable instructional designs for interdisciplinary e-learning teams by analyzing patterns in team behavior: „We introduced the notion of patterns of designing to offer ‘smaller chunks’ of observed team designing behavior, which appear to be more adequate to guide practice. These ‘smaller chunks’ of good practice are more context sensitive and can be reproduced dynamically throughout the ID process. They do not replace larger models, but provide deeper understanding of the design endeavor.” (Rapanta et al., 2013)

The factors that help to predict group intelligence was examined in empiric research (Woolley et al., 2010). Group intelligence in this research was defined by the degree a series of tasks such as analysis, planning and estimation could successfully be completed by a group. While the study found no correlation with the individual intelligence of the group members, the strongest correlation was found in the way they interacted, most of all the conversational turn taking. This research was followed up by what Pentland framed social physics (Pentland, 2014).

Analyzing group interaction is a valuable resource for team coaching for instance in systemic coaching approaches. One systemic coaching technique is to examine differences in the communication and asking what differences they make (De Shazer, 1991).

Discerning and visualizing patterns in online discussion and how this “may help instructors and researchers study, moderate, and/or facilitate group discussions” has been evaluated (Gibbs et al., 2006). Tool-based visualizations of video communication including turn-taking and emotional reactions have been evaluated (Samrose et al., 2018).

Quantifying and diagramming social interactions in groups was already introduced and utilized in social science and practice in the first half of the 20th century (Moreno, 1941). Sociograms were used both for understanding the structure of group communication as well as the position of individual members within a group (Stadler, 2013). With increased availability of digital communication metadata, social network analysis (SNA) provides means to compute metrics regarding the position of members within a group such as centrality or social

prestige. A broad variety of methodical discussions and case studies have covered social network analysis, such as (Wasserman & Faust, 1994), (Huber & Froehlich, 2020) and (Majeed et al., 2020).

Method

Overview

This multiple-case study is following a theoretical replication logic (Yin, 2018): The same research design is applied to two cases. Both cases entail online student discussions regarding the same question in the same university course with the same given time frame of one hour for the discussion. The video recording of the online meeting was then viewed and reflected in an onsite meeting in two steps. At first just based on viewing the video and the personal recollections, then a second time after viewing the communication report of the discussion. Both reflections were captured, and a reflexive thematic analysis was conducted. The second reflection showed what additional insights could be gained by viewing the communication report, thus providing answers to the research questions 1.1 and 1.2.

Context

The participants of this study were master students at the university course social thinking in computer science, a course open to students of all faculties. Students were initially asked whether they wanted to participate in this discussion and whether they would consent to the discussion being recorded and used for this research after the data has been anonymized. Those students who had given their written consent participated in the research.

Binding the cases

To allow for controversy, two groups were formed by selecting representatives from both sides of the opinion spectrum for each group. Before entering the discussion, students were asked to position themselves on a scale from 1 to 10: should Twitter allow all messages to be tweeted regardless of the content (1) or should it block messages that are potentially fake news (10). Each group also had two students who acted as silent observers. Their video was turned off and their microphone was muted, whereas the others could see and hear each other throughout the meeting. The discussion and reflection of one group represents one case in this study. Group 1 had 7 participants, 2 female and 5 male students. Group 2 also had 7 participants, 1 female and 6 male participants.

External views

To prepare for the onsite course meeting, the two lecturers (and authors of this paper) reviewed both videos. After watching the videos, they collected their spontaneous associations regarding the group processes in both groups. Then, a specific interaction sequence that appeared significant to both researchers for changes in group dynamics in one of the groups was selected for a micro-analysis. The transcribed interaction sequence was then discussed sentence by sentence with a focus on assumed intentions, motivations and reciprocal reactions of the interaction partners. This discussion among the lecturers helped to further differentiate group processes within a team and framed the structuring of the communication report for each team.

Evaluation units

The group discussion was then reflected separately by each group. The guiding question of this reflection was: "What contributed to constructive discourse and what hindered it?" The reflection was done in two steps:

1. First, the video of the group discussion was shown, and students were asked to share:
 - a) their observations and
 - b) their interpretations of what had happened in the group discussion.
2. After that, the communication report of the meeting was shown, and students were asked what additional insights they gained from viewing it. For each group those parts of the communication report were selected respectively, that held the most relevant information for the respective group from the perspective of both researchers after viewing the recordings of the discussions.

In each of two steps, students first wrote their answers to the guiding question silently down on sticky notes and then shared them with the others by posting them to a flipchart.

The sticky notes were then transcribed thus forming three separate evaluation units:

1. The observations by all students of a group
2. The interpretations by all students of a group
3. The additional insights gained by all students of a group after viewing the communication report.

The sequence in which the questions were asked was relevant in this study. Since students already had a structured reflection of their discussion before viewing the communication report, the third evaluation unit shows what can be gained from reflecting on the communication report. RQ1.1 and RQ1.2 could be approached by examining in what way the third evaluation unit provided new insights compared to the first two.

Analysis

The reflexive thematic analysis was conducted following the guideline outlined by Braun and Clarke (Clarke & Braun, 2021). In the analysis the individual answers of the students, each written down on a sticky note, served as coding units. As a first step, they were coded following the concepts of Mayring (Mayring, 1994). Mayring distinguishes between deductive and inductive category definition pointing out that “for qualitative content analysis the second approach is very fruitful” (Mayring, 2022). Accordingly, the category system in this study was created inductively. After that themes were defined and adapted in an iterative process. One author provided initial suggestions, which were then reviewed by the other author and revised accordingly.

Results

Case 1

Fig. 2 and Fig. 3 show the communication report for case 1. Fig. 3 shows the interaction between participants. Only interactions of 6 or higher are shown. Participants 1, 4, 5, and 6 all interacted with each other at least 6 times. Participants 2, 3 and 7 did not interact with anyone 6 or more times. Of these three, participants 3 and 2 had the lowest and second lowest airtime of 5.13 and 5.43 percent respectively, while participant 7 had a significant higher share of airtime of 12.41 percent. The airtime of participant 7 was accumulated in one single monologue with hardly any interaction as Fig. 2 shows.

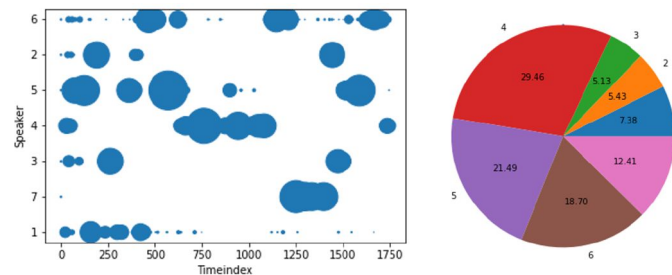


Fig. 2: Communication sequence and airtime distribution of case 1

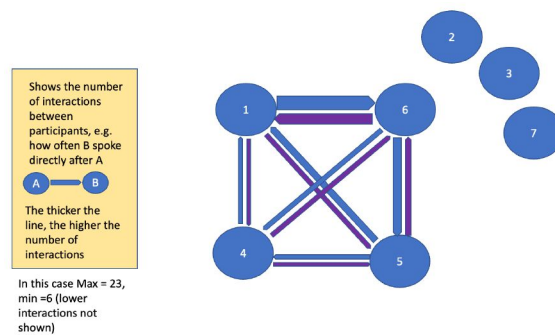


Fig. 3: Interaction diagram of case 1

The impact of monologues was reflected by the team upon viewing the communication report: One theme of their reflection was that “long monologues are detrimental to the discussion flow”. They also noted that “speaking time was unevenly distributed”. One reflection theme delivered an explanation why there was intense interaction between some and hardly any by the other participants: “interaction mainly between those who knew each other beforehand”. The result of the reflective thematic analysis is shown in Table 1.

Observations Themes	Views Themes	Communication Report Themes
precise communication enables constructive dialogue	the discussion was respectful	the frame of the discussion played a role
different opinions foster discourse	different opinions	interaction mainly between those who knew each other beforehand
monologues were hindering, referring to others helped	guidelines would have been helpful	introduction round lead to everybody speaking regarding the topic
mutual respect	knowing one another was helpful	long monologues are detrimental to the discussion-flow
precise communication enables constructive dialogue	no escalations	ones own speaking behaviour (length, concise style, degree of participation) becomes overt
the dialogue was not fluent	remarkable ideas stimulated discussion	reciprocal effects become visible, how oneselves behaviour influences others
the setting of the discussion matters	sometimes nobody took initiative	report changes the perception of one owns behaviour in the discussion
		slow speech speed lead to long speech
		speaking time unevenly distributed
		the flow and interaction of the discussion become visible

Table 1: Result of the reflexive thematic analysis of case 1

Case 2

The discussion can be divided into 4 phases as one participant (participant 1) was cut off from the online call twice. Fig. 5 shows the length of phases 1 and 3 were participant 1 attended, and phases 2 and 4 where he was absent. For technical reasons, participant 1 is sometimes labelled as 1a and sometimes as 1b in the reports, both referring to the same person. The communication report shows that the discussion had different phases with significantly different group interactions. While the airtime distribution is relatively balanced between all participants when viewing the entire meeting as Fig. 4 shows, each of the four phases has very unbalanced airtimes. This particularly goes for phase 4, where participant 4 had an airtime of 61.25 percent, mostly accumulated in a long monologue.

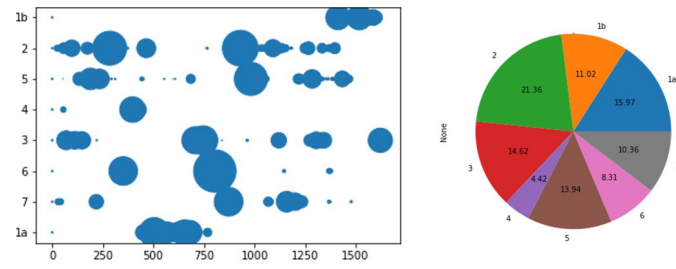


Fig. 4: Communication sequence and airtime distribution of case 2

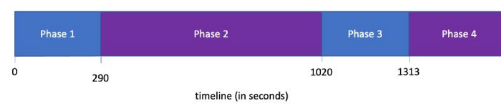


Fig. 5: Phases of the discussion in case 2

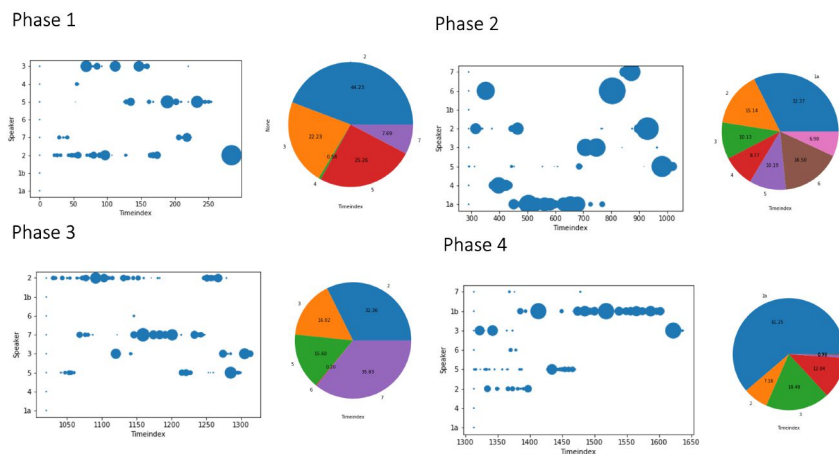


Fig. 6: All phases of case 2 in detail

Table 2 shows the result of the reflexive thematic analysis of case 2. In reflecting the communication report, the group found that the “degree of interaction and people involved varied over time and with topics”. They also reflected the role of participant 1, recognizing that “a game maker energizes the discussion, others stay passive”. Furthermore, they acknowledged the value of a moderator who “ensures flow of discussion”. Another theme acknowledged the value of a position contrary to the group as it “energizes the discussion”.

Observations Themes	Views Themes	Communication Report Themes
low interaction, everybody focused on own position	format unsuitable or not clear enough	a "game maker" energizes the discussion, others stay passive
controversial discussion without final agreement	focus on the extreme opinions (minority), the middle position were lost	a position contrary to the rest of the group energizes the discussion, while others stay passive
hurdles for communication due to online format	it was a discussion for the sake of discussion	atmosphere of discussion was relaxed
inbalanced speaking time	moderator was helpful	controversial topic makes discussion easier and more interactive
low interaction, everybody focused on own position	monotonous discussion full of monologues	degree of interaction and people involved varied over time and with topics
personal mood matters		moderator ensures flow of discussion
polarization one against all occurred meeting		moderator should stay neutral
the framing of the meeting (no clear goal, no rules, no moderator preselected) mattered		
the positions were balanced due to the preselection of participants		

Table 2: Result of the reflexive thematic analysis of case 2

Discussion

Case 1 shows that several aspects of the discussion were only noted by the team after viewing the communication report, for instance that long discussions are detrimental to the discussion flow. This is backed up by empirical research that found that short interaction cycles as opposed to having long monologues in teams are a strong factor in predicting group intelligence (Woolley et al., 2010) and (Pentland, 2014). Furthermore, the reciprocal effects of one's own behavior was noted by the team: the degree to which I participate or whether I manage to speak concisely influences the entire group. The reflection of the report can adjust the perception of one's own behavior: The perceived participation and speaking behavior in the meeting was adjusted after viewing the data provided by the report. Another theme stated that the flow of the discussion became visible through the report. All these aspects were only recognized by the students after reflecting the communication report. Regarding RQ1.1 and RQ1.2 this indicates that a communication report as used here can help to reflect one's own communication pattern in the discussion process: whether I tend to speak short and concise, whether I lean more towards monologues or whether I have more interactive communications, and whether this is helpful to the discussion flow. Furthermore case 1 shows that viewing the communication report can help reflecting the overall communication structure, in this case by identifying a group within the group that is interacting a lot and other participants who are mostly standing on the side-line.

Case 2 shows the impact one "game maker" -as one participant phrased it- can have on the discussion: participant 1 was only present in phases 2 and 4 but took most of the airtime in these phases. As the sequence diagram shows, participant 1 had long monologues with little interactions with others, particularly in phase 4. After viewing the communication report, the value of a person taking a position that is strongly contrary to the rest of the group was appreciated: one theme was that such a "game maker" energizes the discussion. Another theme was that a position contrary to the rest of the group energizes the discussion. Both the value of contrary positions on a content level as well as the behavior of openly and vehemently expressing this contrary position was recognized by the group after viewing the communication report. The role of player 1 opposing the opinion of the rest of the group resembles the omega position in Schindler's sociometric model of rank order in groups (Schindler, 1973). Furthermore, the role of the moderator became visible in the interaction and sequence diagrams, and it was appreciated that he ensured the flow of discussion. Regarding research questions 1.1 and 1.2, this indicates that some role patterns were discerned through reflecting on the report and that this reflection led to an appreciation of these roles.

Conclusions

The two cases show that teams can recognize certain patterns through viewing the communication report in a team coaching setting. Insights were on one hand found regarding roles and their impact on teams. Case 2 for instance showed that the roles of the omega in the group as well as the moderator became more visible. Furthermore,

the value of these roles to the group discussion were expressed. Team members also started to stronger acknowledge the effect of their own behaviour on the group and vice versa. Secondly, there were insights regarding the structure and flow of the communication. Both aspects were intertwined: looking at the flow naturally led to the question what individual behavioural patterns contributed to constructive team communication and what rather hindered it.

With regard to RQ1, these insights found by the students show that university online learning can be facilitated through digitally supported coaching like introduced in this approach. Viewing selected quantitative data visualized in reports tailored to the respective meeting made aspects of the communication overt that had not been recognized even after watching and reflecting on the video of the discussion by the participants and neutral observers. Using the approach introduced here to let teams reflect their interplay as well as their own behaviour has a potential both for team coaching and team learning.

Limitations

This research is limited in so far been only tried for two groups, both in the same context, a university course at the University of Vienna. Further research could explore how useful this approach is in other learnings settings, languages, and cultures. Researcher bias could come from one researcher being a professional systemic coach, and that the approach introduced here was developed by the first author.

Acknowledgements

The authors wish to thank the University of Vienna for the opportunity to conduct this research. Special thanks go to Univ.Prof. Dr. Renate Motschnig and Univ.Prof. Dr. Sebastian Tschiatschek for their invaluable support.

References

- Clarke, V., & Braun, V. (2021). Thematic analysis: A practical guide. *Thematic Analysis*, 1–100.
- Coombs, S. J., & Smith, I. D. (1998). Designing a self-organized conversational learning environment. *Educational Technology*, 38(3), 17–28.
- De Shazer, S. (1991). *Putting difference to work* (1st ed). Norton.
- Gibbs, W. J., Olexa, V., & Bernas, R. S. (2006). A Visualization Tool for Managing and Studying Online Communications. *Educational technology & society*, 9, 243.
- Huber, M., & Froehlich, D. E. (2020). *Analyzing group interactions*. Routledge.
- Majeed, S., Uzair, M., Qamar, U., & Farooq, A. (2020). Social Network Analysis Visualization Tools: A Comparative Review. 2020 IEEE 23rd International Multitopic Conference (INMIC), 1–6. <https://doi.org/10.1109/INMIC50486.2020.9318162>
- Mayring, P. (1994). Qualitative Inhaltsanalyse. In *Texte verstehen: Konzepte, Methoden, Werkzeuge*. UVK Univ.-Verl. Konstanz.
- Mayring, P. (2022). *Qualitative content analysis: A step-by-step guide* (1st edition.). SAGE Publications Ltd. <https://app.talis.com/textbooks/9781529766738>
- Moreno, J. L. (1941). *Foundations of sociometry: An introduction*. Beacon House. <https://ubdata.univie.ac.at/AC11980345>
- Palincsar, A. S. (1998). SOCIAL CONSTRUCTIVIST PERSPECTIVES ON TEACHING AND LEARNING. *Annual Review of Psychology*, 49(1), 345–375. <https://doi.org/10.1146/annurev.psych.49.1.345>
- Pentland, A. (2014). *Social physics: How good ideas spread-the lessons from a new science*. Penguin.
- Rapanta, C., Maina, M., Lotz, N., & Bacchelli, A. (2013). Team design communication patterns in e-learning design and development. *Educational technology research and development*, 61, 581–605.

- Samrose, S., Zhao, R., White, J., Li, V., Nova, L., Lu, Y., Ali, M. R., & Hoque, M. E. (2018). Coco: Collaboration coach for understanding team dynamics during video conferencing. *Proceedings of the ACM on interactive, mobile, wearable and ubiquitous technologies*, 1(4), 1–24.
- Schindler, R. (1973). *Das Verhältnis von Soziometrie und Rangordnungsdynamik*. Heigl-Evers, A.(Hg.): Gruppendynamik. Göttingen: Vandenhoeck & Ruprecht.
- Stadler, C. (Hrsg.). (2013). *Soziometrie: Messung, Darstellung, Analyse und Intervention in sozialen Beziehungen*. Springer Fachmedien Wiesbaden. <https://doi.org/10.1007/978-3-531-18981-9>
- Thomas, L., & Harri-Augstein, S. (2001). Conversational science and advanced learning technologies (ALT): Tools for conversational pedagogy. *Kybernetes*, 30(7/8), 921–954. <https://doi.org/10.1108/EUM0000000005917>
- Wasserman, S., & Faust, K. (1994). *Social Network Analysis: Methods and Applications*. In *Social network analysis: Methods and applications* (Bd. 8). Cambridge University Press.
- Watzlawick, P., Bavelas, J. B., & Jackson, D. D. (2011). *Pragmatics of Human Communication: A Study of Interactional Patterns, Pathologies and Paradoxes*. W. W. Norton. <https://books.google.at/books?id=YcBUAgAAQBAJ>
- Woolley, A. W., Chabris, C. F., Pentland, A., Hashmi, N., & Malone, T. W. (2010). Evidence for a Collective Intelligence Factor in the Performance of Human Groups. *Science*, 330(6004), 686–688. <https://doi.org/10.1126/science.1193147>
- Yin, R. K. (2018). *Case study research and applications: Design and methods* (Sixth edition). SAGE.

11.4 Paper 4: Unveiling Communication Patterns: Helpful Visualizations of Communication in Online Video Conferences

This is the published version of the conference paper by Spielhofer, T., & Motschnig, R. submitted to and published by the *2024 8th IEEE International Symposium on Multidisciplinary Studies and Innovative Technologies (ISMSIT)*.

© IEEE.

Unveiling Communication Patterns: Helpful Visualizations of Communication in Online Video Conferences

Thomas Spielhofer
*Doctoral School Computer Science
 University of Vienna
 Vienna, Austria
 thomas.spielhofer@univie.ac.at*

Prof. Dr. Renate Motschnig
*Faculty of Computer Science
 University of Vienna
 Vienna, Austria
 rene.motschnig@univie.ac.at*

Abstract --- Over the past few years, the number of teams collaborating through video conferences has significantly increased. The research presented in this paper addresses the question of how structural information of online communication can be visualized in a way that enables such teams to learn from it and improve their collaboration. Structural information about communication refers to interaction patterns, airtime distribution, and other data reflecting the communication dynamics of a conversation. By examining six case studies conducted using a participatory design science approach and reviewing previous research, a set of criteria was developed for creating helpful visualizations in these contexts. The data from this research shows that more helpful visualizations were also considered more complex and less easy to read. We, therefore, propose that the setting in which these visualizations are presented should be designed to ensure that the purpose and form of each graphic are adequately explained to the respective recipients. Additionally, the case studies indicated that self-organized teams have a higher affinity for more complex visualizations compared to hierarchically led teams.

Keywords — data visualization, online communication, video conferences

I. INTRODUCTION

A. Aim and theoretical foundation of the study

This research aims to evaluate the creation of visual artefacts reflecting synchronous online team communication. The overarching goal is to help teams to discern their communication patterns.

Following Paul Watzlawick's communication theory "the search for pattern is the basis for all scientific investigation. Where there is pattern there is significance—this epistemological maxim also holds for the study of human interaction" [1]. Communication patterns in this view are defined stochastically: the likeliness of a particular communication to occur in a certain context. Watzlawick links the patterns to the rules of a chess game with the essential difference that "we are particularly unaware of the rules being followed in successful, and broken in disturbed, communication."

What can help us to recognize the patterns in our communication which, according to Watzlawick, are key and which we are oblivious of at the same time? In this research, the learnings of a multiple case-study are examined to propose initial criteria how communication reports can be formed and presented to that end.

These case studies made use of a specific visualization type that is part of the so called Digitally Supported Coaching (DSC) [2]. In DSC, three to five online video conferences per team are processed with the help of a software tool specifically developed for this purpose. Only the audio tracks are used by the software, creating a diarization: A dataset that captures who spoke at what point in time for how long. This dataset is analyzed and used to create different visualizations of the communication. These visualizations are compiled into a communication report (see Fig. 1) that is then reflected with the team as part of a structured team coaching process. This aims to help the team to distinguish between helpful communication patterns and patterns that they might want to change in the future.

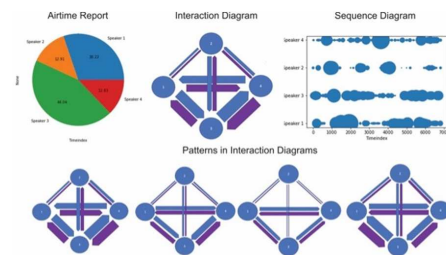


Fig. 1: A sample communication report.

The communication report features different views on communication: The airtime report depicts the share of time each person had for contributing to the communication, the sequence diagram illustrates who spoke at what point in time and reflects the rhythm of the communication: Larger bubbles indicating longer speaking times occur in monologue-like conversations, whereas many small adjacent bubbles would mirror dense interactions between the meeting participants.

The Research Questions (RQ) pursued in this research are:

1. What visual representations are considered helpful by participants of online video conferences to learn about and improve their communication?
2. What level of complexity in visualization is suitable for teams to discern patterns in their communication?
3. What are relevant criteria in designing and conveying visualizations of metadata of synchronous online communication?

The primary user groups for these visualizations are the team members and the coach facilitating the team coaching process. Secondary user groups are managers, executives and human resources departments of the organizations the teams are part of.

B. Criteria for designing the initial communication report

It has been argued that Wittgenstein's work provides an epistemological basis for information visualization design. In specific, that "general insights into image theory can be gained [...] which may be of particular interest for the understanding of 'epistemic images' such as schemata, models or plans and, in the broadest sense, for a theory of the 'diagrammatic'." [3] Wittgenstein in his *Tractatus logico-philosophicus* [4] defines images, like sentences, as models of reality: "Das Bild ist ein Modell der Wirklichkeit." ("The picture is a model of reality"¹, 2.12). He further states that „Jedes Bild ist auch ein logisches.“ („Every picture is also a logical picture“, 2.182). In Wittgenstein's definition, images are composed of elements, which need to be concatenated in a way that must reflect the facts they represent: „Dass sich die Elemente des Bildes in bestimmter Art und Weise zu einander verhalten stellt vor, dass sich die Sachen so zu einander verhalten. Dieser Zusammenhang der Elemente des Bildes heie seine Struktur und ihre Mglichkeit seine Form der Abbildung.“ („That the elements of the picture are combined with one another in a definite way, represents that the things are so combined with one another. This connection of the elements of the picture is called its structure, and the possibility of this structure is called the form of representation of the picture“, 2.15). Concatenations between elements in an image can be metaphorically seen as links in a chain: „Im Sachverhalt hngen die Gegenstnde ineinander, wie die Glieder einer Kette.“ („In the atomic fact objects hang one in another, like the links of a chain“, 2.03) It has also been stated that images in Wittgenstein's sense are "essentially ascribed a formal structure, an 'implicit pattern', which Wittgenstein also identifies as a 'configuration', as 'the changing, unstable' compared to the 'fixed forms' of the world (2.0271, 2.026).“ [3]. For the purpose of this research we can derive from Wittgenstein's work that it is not decisive what colors or forms are used in a visualization type, but that the relationship between the elements used consistently follow an inherent logic.

Further criteria specific to this research can be found in the field of data visualization. Elementary principles on how to display quantitative information have been defined in [5], for instance stating: "Graphical excellence is that which gives to the viewer the greatest number of ideas in the shortest time with the least ink in the smallest place". More recently principles for tool-based data visualization have been stated, proposing: "before you make a visual, prioritize the information you want to share, envision it, and design it" [6]. Moreover, guidelines for data visualization in sociology [7] and psychology [8] have been developed.

One key question in this research (as stated in RQ3) is the extent to which a visualization should reflect the complexity of a subject it represents. This has been addressed in [9]: „As

well as subject complexity, another issue to consider is representation complexity. That is, the perceived complexity of uncommon or unfamiliar chart types. Not every chart we encounter is familiar. And when something is not familiar, it is understandable how this exposes a risk of confusion." It further concludes that one should not shy away to seek an accurate reflection of the data, even if this led to more complex visualization types: "But what if there was good reason to use that chart? It might be the most astute way to portray the most relevant analysis about a subject. Sure, it might be visually complicated, but this might be the only way to show it. Everything is new once. This is why we learn and why we are capable of learning." It suggests that "to overcome chart types that are unfamiliar a viewer must be provided with the means to learn how to perceive and interpret a chart" [9]. Following that line of thought, this paper will not only consider the form in which communication metadata is represented, but also the context and the manner it is conveyed to the recipients.

C. Related Work

Ways of analyzing and visualizing online video communication were described in [10]. Temporal patterns in global virtual project teams were analyzed and visualized to explore "the nature of team interaction and the role of temporal coordination" [11].

[12] evaluated, in how far the visualization of patterns in on-line discussions "may help instructors and researchers study, moderate, and/or facilitate group discussions". The graphical analysis of indicators "which measure the intensity of various aspects of users' communication activity in periodic manner" were examined in [13]. A "visualization system for playful end-user exploration and navigation of large-scale online social networks" was built and examined already as early as 2005 [14].

[15] evaluated a tool that analyzed the online communication of a web-based collaboration system. It featured "three distinct forms of visualizations: workspace network maps, workspace maps, and discussion maps, which are displayed using a modified form of an animated spring algorithm."

There is a long-standing tradition of understanding communication patterns to support therapeutic and coaching processes. In these contexts, "questions are formulated to bring forth the 'patterns that connect' persons, objects, actions, perceptions, ideas, feelings, events, beliefs, contexts, etc., in recurrent or cybernetic circuits" [16].

II. METHODS

This research follows a design science approach. Design science research can be defined as a "research paradigm in which a designer answers questions relevant to human problems via the creation of innovative artifacts, thereby contributing new knowledge to the body of scientific evidence. The designed artifacts are both useful and fundamental in understanding that problem" [17]. The artifacts investigated in this research are the diagrams featured

¹ The English versions of the German texts are the author's translations.

in the communication report (see Fig. 1). Based on [18], the research process was split into three phases: analysis, design, and evaluation. The analysis phase was conducted as literature research and led to the criteria for designing the initial communication report. The design and evaluation phases were done iteratively: The design was adapted after each evaluation based on the feedback received by stakeholders. A first iteration was based on the feedback of fellow-researchers, which led to the version of the communication report that was evaluated in a second iteration. Its results are presented in this paper.

The evaluation was done based on case studies in the defined research context. “Researchers can use case studies to develop detailed understandings of interaction techniques and coping strategies -understandings that might be hard (if not impossible) to develop through usability studies.” [19]. The method of case studies was chosen, as the artifacts under evaluation were both complex and innovative and case studies can provide the in-depth analysis required here. The research was designed as a multiple-case study following a theoretical replication logic as proposed by [20]: the same research questions are analyzed with the same research design in all cases. The cases were selected as the authors had access to the teams and they were willing to contribute to this research.

Cases A, B, and C were teams in hierarchical organizations, cases D, E, and F were self-organized teams. Each case was encompassed by the same group of people working together on shared goals during the observed time period.

The visualizations were evaluated using a questionnaire that each team member filled out anonymously after the DSC team coaching. The questionnaire included the following questions:

1. What report is most helpful to learn about and improve your team communication?
2. What could be added / removed / changed to make this report more valuable to us?
3. Do you have other comments, suggestions, or ideas?

In addressing question 1, each participants had 10 voting points to distribute at will among the four different diagrams. Question 2 could be answered individually for each report. Question 3 was an open question aiming to invite any kind of feedback.

The answers to question 1 were analyzed using quantitative methods. The answers to questions 2 and 3 were analyzed using a summative qualitative content analysis [21]. We created categories inductively from the answers to the questionnaire, with one answer by one participant to one question serving as coding unit. This coding unit was a unit of thought, usually one written paragraph containing one to five sentences. The categories were thematic, all categories referred to some specific aspect of the visualization, such as depicting all meetings on one slide, labelling speakers with their names, or using colors consistently. The codes were further clustered based on reciprocities. Based on that, we constructed a code book, with each entry having the form: “code”, “code count” and “report references”. Findings were sent to a peer reviewer for evaluation and reduction of researcher’s bias.

III. RESULTS

Table 1 shows the answers to Q1: “what report is most helpful to learn about and improve your team communication”. Since the number of participants per case varied, the answers are aggregated as percentage of votes of each case given to each report. E.g. 38% of the votes of the team members in Case 1 were given to the Sequence Diagram as the most helpful report.

Case	Airtime Report	Interaction Diagram	Sequence Diagram	Patterns in Interaction Diagram
A	27%	14%	38%	22%
B	20%	17%	40%	23%
C	13%	27%	23%	37%
D	9%	9%	9%	73%
E	20%	28%	8%	45%
F	24%	32%	22%	22%

Table 1. Votes per Report and Case in percentage of total votes.

On average, the reports got 19, 21, 23 and 37 percent of the votes respectively. The results show that all diagrams are considered as valuable by at least one team: Every diagram has a team that voted it to be most helpful with more than 25% out of the 4 options. All four diagram types also inspired the participants to share ideas how the visualizations could be further improved as Table 2 and Table 3 show.

The interaction diagram is similarly popular as other diagrams representing one meeting, but by far the most popular when reflecting several meetings, as is done in the Patterns in Interaction Diagram. Furthermore, the Patterns in Interaction Diagram has a significantly higher variance in votes than the other diagrams. It is significantly more appreciated by the three self-organized teams (giving an average of 47% of the votes to this diagram), than by the hierarchically led teams (giving an average of 27% of the votes).

Airtime Report		Sequence diagram	
Codes	Code Count	Codes	Code Count
Label speaker with names	2	Show interruptions	3
Nothing to add	1	Specify unit of measurement	3
All meetings on one slide	1	Add info about emotions of participants	2
Same colors for participant throughout all reports	1	Additional overlay of all speaker sequences	2

Table 2. Qualitative Analysis of Q2 for Airtime Report and Sequence Diagram (only the four codes with highest counts are shown).

Interaction Diagram		Patterns in Interaction Diagram	
Codes	Code Count	Codes	Code Count
Add caption in diagram	4	Diagram not easy to read	1
Diagram not easy to read	3	Add chart with averages	1
Nothing to add	1	Can later reactions be shown in diagram?	1
Add airtime diagram to interaction diagram	1		

Table 3: Qualitative Analysis of Q2 for Interaction Diagram and Patterns in Interaction Diagram (only the four codes with highest counts are shown).

The answers to Q2 (as shown in Table 2 and Table 3) provide some detailed feedback by the teams on how to improve the visualizations. Particularly interesting statements regarding RQ3 are:

- Add caption in diagram
- Use same colors for participant throughout all reports
- Add chart with averages
- Specify unit of measurement

When also looking at the answers of Q2 and Q3 (see Table 2, Table 3, and Table 4) further reaching suggestions on how to extend the reports can be found. The current version of the communication report, reflecting the interaction of a team, could be combined with:

- Measuring emotions of the participants (“Add info about emotions of participants”, “Measure mood of the participants”),
- Meeting content (“Add meeting content summaries to diagrams”),
- The organizational context (“Correlate individual behavior with company role”).

Code	Code Count
Add meeting content summaries to diagrams	4
Correlate individual behavior with company role	2
Measure mood of the participants	2
Reports helpful for self-reflection	2
Add meeting type	1
Are there differences between digital and real meetings?	1
Display total length of the recording	1
Have meeting prescriptions	1
Highlight interactions between subgroups	1
Show interruptions on diagrams	1

Table 4: Qualitative Analysis of Q3.

Other feedback in answering Q3 that occurred more than once stated that the reports are “helpful for self-reflection”.

IV. DISCUSSION AND CONCLUSIONS

A. Contribution, Implications, and Further Work

The perceived value of each diagram examined here strongly varied with the team members and their context. This is most significant with the Patterns in Interactions Diagram. One possible explanation for this might be that this diagram is more difficult to read, but insightful when properly explained and understood. This is supported by one feedback to Q2 that this diagram is “not easy to read” (see Table 3). Another significant finding is that the Patterns in Interactions diagram is considered as more helpful by self-organized than by hierarchically led teams. This might be due to the fact that leadership in self-organized teams is strongly subject to a group-dynamic process, as there is no formally defined leader. A Patterns in Interaction Diagram can be used to understand the centralities of people and how they change over time, a relevant indication for reflecting (leadership) positions within a team. Something that might be more relevant to ponder in teams where leadership is not formally defined. Regarding RQ1, we can conclude that for the complex subject of human communication, it makes sense to provide a variety of visual representations, each conveying different aspects of human interaction.

The feedback also shows that the reports are “helpful for self-reflection” (see Table 4), indicating that these visual representations of communication reach beyond being helpful to learn about the communication of the group as a whole. They can also be used to learn about individual behavior in the given social context. The sequence diagram for instance is a way to realize whether one tends to have short contributions or rather long monologues. The interaction diagram can be used as a basis for social network analysis (SNA), as has been previously argued [2]. When used for groups, a SNA allows for the analysis of the communication structure, as well as individual positioning of team members [22]. This could be further supported in future versions of the communication report by showing SNA metrics, such as centralities, for all team members on the diagrams. As with any intervention that creates transparency in a social context this would have to be weighed against potential downsides, since the positioning within a team is a sensitive issue. As experience in team coaching indicates [23], a team member, whom the SNA shows at the rim of the team, might not want to be openly confronted with this fact.

Regarding RQ2, we can put forward the hypothesis that among the evaluated diagrams, the Patterns in Interaction diagram is a particularly good base to discern patterns in communication. The results of this study only back this up in so far, as this diagram type received the most votes as being the most helpful diagram (see Table 1). Further research would be needed to compare more diagram types and evaluate which are best suited to detect communication patterns. However, the nature of this visualization type seems like a promising base to discern structural similarities in team communication. Firstly, by concisely showing structural information about several meetings beside one another. Secondly, they, like sociograms [24], reflect the relationships between team members and their positions within the team. As the Patterns in Interaction Diagram spans several meetings, it also allows to discern changes in these relationships and positionings.

The feedback also shows, that the search for communication patterns can be further enhanced when for each meeting the Patterns in Interaction Diagram is complemented with the Airtime Diagram as suggested in one of the answers to Q2 (see Table 3).

Another feedback by the teams show that some diagrams are difficult to read (see Table 3). Therefore, it appears to be of central importance to cater the way the diagrams are conveyed to the individual needs of the respective recipients. Some people might be able to intuitively understand sociogram-like visualizations, others might need to be first introduced to it more profoundly.

Further-reaching feedback by the teams in these six cases provides suggestions on how the reports could be developed into a more holistic mirror of online communication. Suggestions reach from measuring the emotions of meeting participants to using the content level of the communication and bringing in the organizational context. As with any data visualization, the purpose should dictate what elements are selected to be shown.

With regard to RQ3, we propose the following three initial criteria for designing communication reports for online video conferences from the feedback. As the DSC and the diagrams created in its process only make use of the audio data, we further propose that the scope of this criteria can be extended for creating visualizations of any kind of synchronous online communication between humans. The limits to which this proposition holds yet need to be explored in further research:

1. Homogeneity of the form: All elements used should consistently follow an inherent logic. E.g. the same colors for participants should be used throughout all diagrams.
2. To manage the complexity of visual representations, it is helpful to distinguish between the layers of communication that are represented, and choose them according to the purpose of the visualization:
 - a. Structural information.
 - i. Communication of the entire team, e.g. communication patterns or structural SNA metrics, such as the reciprocity of relations.
 - ii. Individual communication behavior, e.g. speaking times, speaking rhythm, as well as individual SNA metrics such as centrality.
 - b. Content, e.g. word clouds featuring summaries of meetings or meeting phases.
 - c. Emotions, as can be deducted by changes in pitch and volume in audio tracks, by facial recognition in video feeds or sentiment analysis of the communication content.
3. The complexity of the process of conveying the diagrams should match the complexity of the subject that is being conveyed. The process of explaining the form that is chosen to represent a certain aspect of communication should be tailored

to the recipients, considering their previous knowledge and their needs.

B. Limitations

The findings outlined here apply specifically to the context of the case studies. More case studies in different cultural, organizational, and social contexts would be necessary to corroborate or refine the findings. In this research, the reports used are part of the DSC. Other reports featuring different types of visualizations might lead to new insights.

C. Conclusions

This research provides insights into how human communication, in its multi-layered richness, can be depicted in a way that teams can learn from. While established good practices for data visualization hold true in this context, it is particularly important to start by considering the purpose and the target group for which communication is being visualized. Based on that, the relevant aspects of communication and the appropriate diagram types can be selected. Lastly, since in diagrams representing synchronous human communication complexity cannot always be avoided, it is highly relevant to consider how the visualizations are conveyed and what contextual information is provided alongside them.

ACKNOWLEDGMENT

The authors wish to express their sincerest thanks to the teams participating in this research, as well as to the University of Vienna, in particular Dr. David Haselberger for their support.

REFERENCES

- [1] P. Watzlawick, J. B. Bavelas, and D. D. Jackson, *Pragmatics of Human Communication: A Study of Interactional Patterns, Pathologies and Paradoxes*. W. W. Norton, 2011. [Online]. Available: <https://books.google.at/books?id=YcBUAgAAQBAJ>
- [2] T. Spielhofer and R. Motschnig, 'Developing Teams by Visualizing Their Communication Structures in Online Meetings', *MTI*, vol. 7, no. 10, p. 100, Oct. 2023, doi: 10.3390/mti7100100.
- [3] D. Mersch, 'Wittgensteins Bilddenken', *Deutsche Zeitschrift für Philosophie*, vol. 54, no. 6, pp. 925–942, 2006.
- [4] L. Wittgenstein, *Tractatus logico philosophicus*, 7. Aufl. in Edition Suhrkamp, no. 1322. Frankfurt am Main: Suhrkamp, 2014.
- [5] E. Tufte and P. Graves-Morris, 'The visual display of quantitative information.; 1983', *Diagrammatik-Reader. Grundlegende Texte aus Theorie und Geschichte*. Berlin: De Gruyter, pp. 219–230, 2014.
- [6] S. R. Midway, 'Principles of Effective Data Visualization', *Patterns*, vol. 1, no. 9, p. 100141, Dec. 2020, doi: 10.1016/j.patter.2020.100141.
- [7] K. Healy and J. Moody, 'Data visualization in sociology', *Annual review of sociology*, vol. 40, pp. 105–128, 2014.
- [8] H. Kennedy and R. L. Hill, 'The feeling of numbers: Emotions in everyday engagements with data and their visualisation', *Sociology*, vol. 52, no. 4, pp. 830–848, 2018.
- [9] A. Kirk, *Data visualisation: a handbook for data driven design*, Second edition. Los Angeles: SAGE, 2019.
- [10] S. Samrose *et al.*, 'Coco: Collaboration coach for understanding team dynamics during video conferencing', *Proceedings of the ACM on interactive, mobile, wearable and ubiquitous technologies*, vol. 1, no. 4, pp. 1–24, 2018.
- [11] A. P. Massey, 'Because Time Matters: Temporal Coordination in Global Virtual Project Teams', *Journal of Management Information Systems*, vol. 19, no. 4, pp. 129–155, Apr. 2003, doi: 10.1080/07421222.2003.11045742.
- [12] W. J. Gibbs, V. Olexa, and R. S. Bernas, 'A Visualization Tool

- for Managing and Studying Online Communications', *Educational technology & society*, vol. 9, p. 243, 2006.
- [13] K. Muszyńska and J. Swacha, 'Periodic Indicators for Graphical Monitoring of Team Communication in Information System Development Projects', presented at the 29th International Conference on Information Systems Development, Valencia, Spain, Sep. 2021.
- [14] J. Heer and D. Boyd, 'Vizster: Visualizing online social networks', in *IEEE Symposium on Information Visualization, 2005. INFOVIS 2005.*, IEEE, 2005, pp. 32–39.
- [15] R. P. Biuk-Aghai, 'Visualization of interactions in an online collaboration environment', in *Proceedings of the 2005 International Symposium on Collaborative Technologies and Systems, 2005.*, St Louis, MO, USA: IEEE, 2005, pp. 228–235. doi: 10.1109/ISCST.2005.1553317.
- [16] S. Wasserman and K. Faust, *Social Network Analysis: Methods and Applications*, vol. 8. in *Structural Analysis in the Social Sciences*, vol. 8. Cambridge: Cambridge University Press, 1994.
- [17] A. Hevner and S. Chatterjee, *Design Research in Information Systems*, vol. 22. in *Integrated Series in Information Systems*, vol. 22. Boston, MA: Springer US, 2010. doi: 10.1007/978-1-4419-5653-8.
- [18] H. Österle *et al.*, 'Memorandum on design-oriented information systems research', *European Journal of Information Systems*, vol. 20, no. 1, pp. 7–10, Jan. 2011, doi: 10.1057/ejis.2010.55.
- [19] J. Lazar, *Research methods in human computer interaction*, 2nd edition. Cambridge, MA: Elsevier, 2017.
- [20] R. K. Yin, *Case study research and applications: design and methods*, Sixth edition. Los Angeles: SAGE, 2018.
- [21] U. Kuckartz, *Qualitative Inhaltsanalyse: Methoden, Praxis, Computerunterstützung*, 4. Auflage. in *Grundlagentexte Methoden*. Weinheim Basel: Beltz Juventa, 2018.
- [22] M. Huber and D. E. Froehlich, *Analyzing group interactions*. Routledge, 2020.
- [23] W. Polt and M. Rimser, *Aufstellungen mit dem systembrett: Interventionen für coaching, beratung und therapie*. Ökotopia Verlag, 2006.
- [24] J. L. Moreno, *Die Grundlagen der Soziometrie: Wege zur Neuordnung der Gesellschaft*, Unveränderter Nachdr. der 3. Aufl. Opladen: Leske + Budrich, 1996.

11.5 Paper 5: Framing self-organized online team collaboration in a higher education course on Informatics and Society

This is the published version of the conference paper by Spielhofer T. & Haselberger D. submitted to and published by the *2021 IEEE Frontiers in Education Conference (FIE)*.

© 2021 IEEE. Authorized licensed use limited to: Vienna University Library.

Framing self-organized online team collaboration in a higher education course on Informatics and Society

Thomas Spielhofer,
Faculty of Computer Science
University of Vienna
Vienna, Austria
thomas.spielhofer@univie.ac.at

David Haselberger,
Department for Teacher Education
University of Vienna
Vienna, Austria
david.haselberger@univie.ac.at

Abstract— This Full Paper in the Innovative Practice track describes a new approach towards online agile teamwork in a higher education context. The presented learning format is based on the agile epic bedtime story game and the concept of self-organized learning. It focuses on time-constrained teamwork, with the aim to achieve a shared result from the work of several loosely connected teams through iterative learning and feedback loops within and across teams. We previously successfully applied and evaluated this team collaboration format in onsite learning. In this online adaptation, the efficiency of this approach is complemented with team-building exercises, to somewhat compensate for the lack of social interaction that is inherent to online communication. This approach combines the idea of agile gamification in education with previous concepts of self-organized learning (S-O-L) and the container-differences-exchange (CDE) model to organize self-organization. The infrastructure prerequisites for this format are moderate: a tool for video conferencing, a digital whiteboard and a digital collaborative writing tool. The online learning format was implemented and evaluated in an undergraduate University course on Informatics and Society in autumn 2020 with 36 participating students. We conducted a summative qualitative content analysis of student reports to examine the effect this format has both on the learning experience as well as the social interaction between participants. Self-organized teamwork appeared viable for learning: Students rated the question how well it enabled them to learn the content of the course with a median of 8 on a scale from 1 (worst) to 10 (best) and a standard deviation of 1.5. Students considered iterative work in the same team productive, while communication across teams was perceived challenging. Teams established continuity in their communication, also between sessions, through freely available communication tools. The single most important factor to help social interaction mentioned by students was the use of breakout rooms.

Keywords—Self-Organized Learning, Gamification, Online Learning, CDE Model

I. INTRODUCTION

The sudden shift in university education from onsite to online learning in 2020 imposed new challenges to teachers and students alike. While we prepared an undergraduate course on computer science and society at the University of Vienna, Austria, we were seeking ways to mitigate the lack of personal interaction in an online format. Our goal was to best enable the online learning experience of students as well as to create a virtual space for interpersonal interactions. Social

interactions in universities have starkly suffered with campus life being supplanted by online learning.

The learning approach we chose makes a basic assumption: that learning can be greatly improved when people get in a playful mood, e.g. by framing the course to a playing field where teams produce something in a game-like setting. In this approach, learning is enabled by giving teams a clear learning goal and providing an adequate frame and support for self-organized team collaboration.

Agile methods have become increasingly prevalent in software development over the past decades and have spread to many other business domains, as diverse as the cosmetics and automotive industries [1]. The agile manifesto [2] which captures the main principles these methods follow, postulates (among other points) that self-organized team work, face-to-face communication and the flexibility to respond to changes are key success factors in solving complex tasks. To convey agile methods and agile principles and to foster the learning of self-organized teams, a variety of gamification approaches have emerged in the agile community.

Building on the positive experience on the gamification epic bedtime stories approach in previous semesters [3] we adapted this format to online learning. The original Epic Bedtime Stories approach is tailored for practical experience in and to improve scaled agile teamwork. Several teams create a document together in a time constrained setting. Their challenge is not only to create a chapter per team, but each team also has to meet the predefined acceptance criteria within a timeframe of typically 2 to 4 hours (Fig. 1).

In this gamification approach, one of the lecturers takes the role of the so-called creator. This person explains the objective and acceptance criteria of the document to the teams and gives regular feedback on how well this objective is met after each iteration of the document creation process.

Applying this agile approach to an educational context provides an interactive format to convey the content of the course. Additionally, it also creates a learning opportunity for students to experience time-bound teamwork and to reflect on what makes collaboration effective in reaching goals.

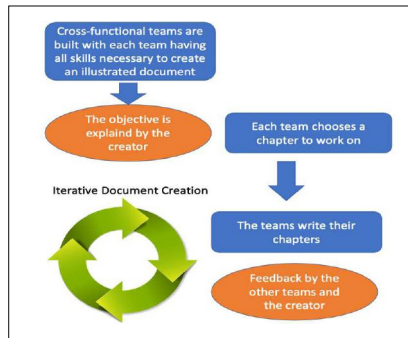


Fig. 1: Epic Bedtime Story Process

This process also mirrors the communication complexity of (small) organizations in so far as the teams have to collaborate to ensure that their combined chapters compose a consistent overall document.

To adequately frame the self-organized learning in this course we found inspiration in the container-differences-exchange (CDE) model [4] that the first author had previously used for team coaching and trainings in business contexts. This model features the concept of a container for self-organization, which is composed of organizational and technical constraints aiming to set an adequate frame for self-organized collaboration: A frame should not be too wide, to avoid communication becoming chaotic, and not too narrow to avoid dampening the creative potential of the participants. To meet that end, the frame needs to be continuously adjusted by mindfully observing the verbal and non-verbal signals coming from the learning group.

At the end of the course, we asked the students to fill out a questionnaire to learn more about our main research question (RQ1): *How can a university course be arranged to support self-organized online learning (SOOL)?* 36 out of the 38 students who signed up for the course replied. Their answers were the basis for the summative qualitative content analysis presented in this paper.

Next, we examine related approaches of applying agile methodologies and compare current online team collaboration strategies in University contexts. In Section 3, we outline our educational approach including the concept of the agile epic bedtime story process adapted to online higher education. Subsequently, we present the findings of our qualitative content analysis on students' learning experience. Finally, we discuss students' feedback in the context of the CDE model and propose suggestions for enabling learning through online team collaboration in University courses.

II. RELATED WORK

Collaboration is pivotal in industry and academic work environments. Several studies highlight that an agile learning environment can effectively support students' learning in collaboration and self-organization [5] [6]. Online

collaborative learning is challenging due to communication barriers, differing skills or expectations, or trust among team members [7] [8]. Due to the COVID-19 pandemic, didactical approaches need to be adapted or introduced to foster collaborative learning among engineering students in distance learning [9] [10] [11] [12]. Effective online education may help in building relationships and to engage students. It is based on timely personal interaction, clear communication and organization, appropriate technology, flexibility and high expectations [13]. An agile approach towards online collaborative learning can support task management and group dynamics [8]. In agile learning environments, teams work iteratively, receive incremental feedback, and discuss steps to be taken [6]. A preparation phase may support initial team structuring [14].

Gamification can already be considered an established approach in business. As far back as 1984, research on applying gameplay at work was conducted, pursuing the question "why do people put up to ten times as much energy and effort into their avocations as in their vocations?" [15]. It was hypothesized that the answer, among others, can be found in clearly defined goals, more frequent feedback and the feeling of participants that they have a higher degree of choice in games, particularly when it comes to the choice of the methods they use. All of these principles are incorporated in agile games such as Lego4Scrum [16] or Epic Bedtime Stories.

A neuropsychological perspective posits that when playing, our brains establish a particularly high number of new synaptic connections that can help unfold new potentials [17]. When we analyze communication as interaction of individuals, we can view them as "Games people play" [18]. From an organizational perspective, then, communication patterns in organizations can be seen as game rules [19]. A further step postulates that the roots and essence of organizations lie in building and strengthening social formations through games and rituals [20]. This knowledge has been extensively applied in business by using gamification approaches in team building and even organizational development. It has also been pointed out how social learning processes on team and organizational level can be fostered through gamification [21].

Gamification as means for education has increasingly become a focus of scientific research over the past decade. The number of articles published between 2010 and 2014 has risen from 10 to 50 [22]. A study of 754 gamification cases found that in business contexts, gamification is used for a variety of purposes, first of all Human Resource Management (HRM), closely followed by training: "HRM (148/754, 19.7%) had a relatively large proportion among the categories, followed by training (143/754, 19.0%), social issue (133/754, 17.7%), education (127/754, 16.9%), commercialization (108/754, 14.3%), and lifestyle (95/754, 12.6%)." [23].

A systematic mapping study of gamification in education showed that "the use of educational games as learning tools is a promising approach due to the games' abilities to teach and the fact that they reinforce not only knowledge but also important skills such as problem-solving, collaboration, and

communication.” [24]. However, self-organized learning through gamification, does not appear as a category in this study, unlike in the business domain.

A well examined example that transfers gamification for the purpose of education into an online setting is the Crystal Island Learning Environment [25]. This game features a 3D virtual environment in which students can collaborate to solve tasks. This required substantial investment in creating the computer game itself as well as the computational models simulating the reaction to the students’ actions. Empirical analysis evaluating the effectiveness of this approach found that it “did exhibit learning gains, but that those gains were less than those produced by traditional instructional approaches. However, the motivational benefits of narrative-centered learning, particularly with regard to self-efficacy, presence, interest, and perception of control, were substantial” [26].

At the core of agile learning is the principle that self-organizing teams are best suited to accomplish complex tasks. Agile coaching and teaching can be seen as ways of strengthening the ability of a team to continuously learn and improve in a self-organized way [27]. The idea of self-organized learning (S-O-L) is even older than agile methods [28]. There has also been research on suitable environments for self-organized learning. From a person-based psychological perspective, it has been argued that “the S-O-L practice depends on the ability of the learner to self-monitor and control the learning process.” [27]. It further stated that “shared meaning is negotiated conversationally from social networks. Such social networks can be understood as conversational learning environments that construct their own viability and validity, resulting in a capacity for creative and flexible thinking” [27]. The role of the teacher is considered to be a learning coach who uses appropriate conversational tools and reflective techniques to facilitate the student’s learning. His/her task is to build an appropriate environment that enables meaningful conversation, e.g. through conversational templates.

The CDE model is “a qualitative conceptual model of a set of meta-variables that represent a wide variety of constraints that influence the speed, direction, and outcomes of self-organizing processes in human systems” [4]. This model distinguishes between:

1. The container in which communication happens
2. The differences in communication (e.g. from iteration to iteration) from which the teams can learn
3. The exchange of teams with the outside

The CDE model draws from systemic and complexity theories including the systems theory by Niklas Luhman [29]. In this view, social systems are complex adaptive systems that display self-organization if they have no central command and control structure. The container in the CDE models is meant to adequately constrain the freedom of self-organization. “We often complain about constraint. Yet, high levels of agreement and certainty within a system result from constraints that reduce the system’s degrees of freedom [30].” It “makes the emergent patterns manifest, so that everyone involved in the project is able to see and name them [30].” To make

differences in communication patterns manifest in order to learn from them is an approach also used in systemic coaching [31].

III. DIDACTICAL CONCEPT AND EDUCATIONAL APPROACH

The approach introduced in this course combines these three ideas: It intends to provide (1) an adequate frame for self-organized online learning (SOOL), with (2) the gamification approach Epic Bedtime Story providing an iterative series of collaboration and conversational templates for reflection and (3) the CDE model as framework how to organize self-organization.

Adapting the Epic Bedtime Stories approach to a University setting, we developed the following procedure: The first three-hour unit is dedicated to getting the participants to know each other better through various exercises and to then form teams. In one of these exercises, students rate themselves on the essential four skills needed for this venture. This allows them to form teams with a balanced set of diverse skills. This is followed by a series of random breakout sessions where students can introduce themselves to one another in small groups of 4-5 people. Based on that, students build teams themselves, simply by putting their names into one out of six team buckets on a digital whiteboard.

As part of the first session, the students also receive short input on the subject matter. Each team then selects a chapter and is tasked to prepare an initial draft of this chapter for the next session. This kind of self-organized team building is (among others) used by agile methods such as Large Scale Scrum [32] and has been prevalent in agile business contexts for several years.

In the second session of 3 hours, the teams then write the booklet together. This is done iteratively: after half an hour work, the teams show their results and receive feedback by other students and the lecturers, which they can incorporate in the next iteration.

In this case, the students’ objective was to write a “Survival Guide to Online Education” comprising of the following chapters:

1. Establishing friendships
2. Team collaboration at university courses
3. Keeping oneself well-informed through online media
4. Keeping oneself well-informed on happenings at University
5. How to fail every single exam in spite of putting in a lot of effort
6. Self-defense against cyber mobbing aka defense against the dark arts
7. Joker: topic to be chosen freely by the team

Following the idea of self-organization, our main role was not as knowledge experts but as facilitators to create an environment for the teams to playfully learn. To establish the different levels of interventions we had at hand, we used the CDE model to understand and enable self-organization.

The container in our course was for one set by the technical constraints of online collaboration. Our goal here was to harness the available tools as much as possible, e.g. by encouraging students to keep video turned on throughout the session and to provide additional tools such as digital whiteboards with carefully customer-tailored templates. The container in the CDE model is also formed by the spoken or otherwise conveyed organizational rules. In the context of this course, a grade-point system and other ground rules served as additional organizational boundaries.

We sought to make clear communication rules by asking students at the beginning of the course, to participate at any time, to speak up when anything was unclear or when something didn't make sense. The intent was to set an example for an open atmosphere where any constructive participation was embraced. Furthermore, we provided questions for the team retrospectives. These questions were based on the practices in agile coaching [33] and systemic coaching [31].

Facilitating self-organizing also requires providing various forms of exchange for the teams. In our case exchange was built into the game: firstly, at the iterative reviews where other teams and we as teachers gave feedback which could be incorporated immediately in the following iteration. Secondly, through so-called guilds, where the settings changed: instead of the cross-functional teams, where they worked in continuity in and between the modules, course participants found themselves in a new social composition: among other experts with a similar focus e.g., graphics or writing.

This approach creates learning opportunities for students on three levels:

- On the content of the booklet created: Getting feedback from the other teams and the lecturers and having the chance to incorporate this feedback several times, the students can improve their understanding of the subject matter step by step.
- On teamwork: how to produce valuable results in teams under time constraints and to experience the increase in communication complexity when several teams need to coordinate. These are situations they will likely encounter in their future work life as software engineers.
- To learn how to best adapt their university education to online settings.

To further enhance these learning opportunities, the teams briefly reflect on their experiences after each iteration, called retrospective, following the Scrum approach [34].

The final product students created together comprises 30 A5 pages available here: <https://rb.gy/6xnuhf>.

IV. METHOD

To evaluate the students' experience in self-organized learning, we asked them questions about their online agile team collaboration. In particular:

RQ1: How can a university course be arranged to support self-organized online learning (SOOL)?

To gain insights on students' perception of key context factors supporting SOOL, we differentiate further:

RQ1.1: What are the relevant factors in the frame of the course to enable SOOL?

RQ1.2: What infrastructure is necessary for successful SOOL?

After two online collaboration sessions, students were invited to give individual feedback on their perceptions of the time-constrained online teamwork answering seven guiding questions, two of which were scaled:

1. On a scale from 1 (worst) to 10 (best), how well did the way we worked together in these two sessions enable you to learn about the content of the course? (Given the available time and the fact that online communication was mandatory)
2. On a scale from 1 (worst) to 10 (best), how well did the way we worked together in these two sessions enable you to better get to know your fellow students? (Given the available time and the fact that online communication was mandatory)
3. What helped in getting to know fellow students?
4. What hindered getting to know one another?
5. What in the way we worked together in these two sessions could have improved your learning experience?
6. What infrastructure enhancements (tools, ...) could have improved your learning experience?
7. In this second session today: how, in your own words, did communication unfold in your team and across teams? (Describe in two paragraphs)

We analyzed student reports in a summative qualitative content analysis [35]. The sampling unit of our analysis was the course on "Computer Science and Society" in the winter term of 2020. Our recording unit is 36 reports (n=36) of 38 course participants in total. Our coding unit was a unit of thought, usually a written paragraph. Reports were anonymized for evaluation.

We created categories inductively from students' written accounts. Our categories were thematic, referring to specific arguments or topics, and analytical, in that codes were further clustered based on reciprocities. We constructed a code book in the form of a hierarchical category system: code/subcode.

First, we defined the structure of the code book, with each entry having the form: "code", "code count", "report references", "anchor example", "tags and question of interest". We coded three reports as reference cases together, adapted the code book structure and subdivided the coding of the rest of the reports among the authors. Reports were then coded by the authors separately. In several iterations, code definitions were discussed and adapted, if required. Finally, we clustered groups of related codes together. In total, we coded 91 codes, of which 29 had more than one occurrence in student reports, with 127 subcodes. Sixty-two codes had no subcodes and were only coded once. We excluded these from the results. Findings were sent to an external auditor for evaluation.

V. RESULTS

The results of the two scaled questions in the questionnaire (Q1, Q2) are depicted in Fig. 2. Student answers can be found on scales between 1 ("worst") and 10 ("best") respectively.

The median of the replies for both questions is 8, with the standard deviation of Q2 with 2.5 being higher than the one of Q1 which was 1.5. Whether this learning approach facilitated students learning was rated on or above the mark of 7 by 75% of the participants. Opinions were more widespread regarding the question how well this format enabled students to get to know one another. Here, agreement of 75% of the participants was only reached with mark 5 and above.

The correlation coefficient between the two datasets, the answers of Q1 and Q2, shows a weak positive correlation of 0.15 (Fig. 2).

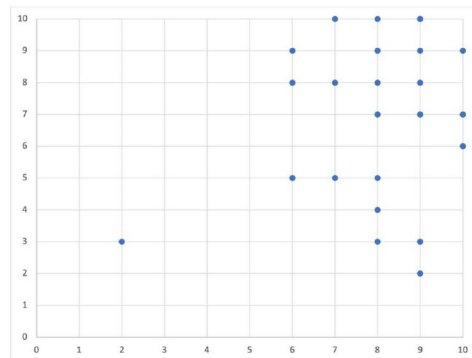


Fig 2. Results of scaled questions. The x-axis shows the answers to Q1, the y-axis shows the answers to Q2 for each student

Table 1 enlists all codes with at least two occurrences alongside anchor examples. The most prevalent codes were “Breakout rooms good to get to know people” and “Communication within the team worked very well” which were coded in 21 of 36 (58%) participant reports.

TABLE I. CODES, OCCURRENCES AND ANCHOR EXAMPLES

Code	#	Anchor Examples
Breakout rooms good to get to know people	21	It was helpful to join in a random room in BreakOutRooms. In a small group, it was easier to overcome awkwardness and uncertainty
Communication within the team worked very well	21	We discussed all of the mistakes and inconsistency with assigned task and tried to improve our paper.
Keeping contact	16	For the small group assignment with the use of discord we arranged a meeting once in every week, which allowed us to keep track of where we stand in our assignment process. In those sessions, although not drastically, we get to know each other better.
Assignment clearer	13	I think the Survival Guide assignment could have had some clearer instructions, because my team used Overleaf/Latex for our guide, so when we had to paste our guide into the shared Google document it was quite difficult. If had we known about that we would have used something else instead of Overleaf.

Communication across teams worked less well than within team	12	Communication worked well in my own group, but less so with the other groups.
Tools sufficient	11	In my opinion, we had everything to become a successful collaboration. Our group used two apps for interaction with each other, Whatsup to appoint date and time when we make cooperate call, and Discord where we shared all our ideas and shared information. Also, we used a Google Documents file where everyone pasted their parts of a text and could make changes in it.
Full participation with video and audio	10	Not everyone in the Breakout-Rooms had their microphone turned on (or their microphone didn't work) which made the communication not as smooth as it could have been.
More time in breakout rooms	9	The communication between the guild members was also very good. We all switched to the guilds that we were interested and having a common subject of interest made the communication easy. The difficulty was having a very restrictive time limit which may affect the end result, thus the outlook of the whole guide.
Blind dates helped to get an idea who the other students were	8	The “Blind-Dates” we had before getting together in groups helped to get an idea of who the other students are.
Discord was helpful	8	My team and I used Discord for communication for our team project and for communication during the lecture (For example on deciding who should present the guide that we've created).
Not meeting in person; online not as personal as face-to-face	8	Communicating face to face, of course. In my opinion, you can only really get to know each other when you meet offline.
Guilds helpful	7	In the session with people from the other groups, the discussion was surprisingly very sophisticated at the time, but then again, the discussion was between people who had proficiency in the same skill. It was engaging, and everyone was able to point some problems out in the document, and everyone was very open.
Working in small teams	7	For me personally working in teams was a completely new experience in this semester and it helped pretty much to get to know each other, to learn how to work together and organize ourselves to achieve a common goal.
Communication across teams worked well	3	Everyone was respectful while communicating and there was no “destructive behavior”
Lack of participation by fellow team members	3	A lot of people claimed to not have a functioning microphone (over a prolonged period of time), which was - at best - a dubious excuse for not wanting to talk to other people. Others did not even bother to come online and attend our group discussions during the beforehand agreed upon time.

Team members who chose whom they knew (sympathetic)	3	To be honest with you, which is also the point of this review, I did not make sure that I got into a team where everyone has a competence that is great for the team, but instead looked to team up with people, which I do previously found sympathetic.
Alternative to allow for less chaotic collaborative work on overall document	2	When working together on the prototype of the guide, you could have found an alternative where everything takes place in a more orderly manner and not everyone changes something at the same time.
BBB for connecting with each other	2	We used BigBlueButton, a presentation platform, which enabled us to connect and work together, and with the help of Clipboard, we could build our team and met other students.
Contents for informatics and society were not in focus, rather communication and team building	2	The focus of the course part was very much on (online) communication / team building / jointly managing a project. That was good in itself, I just found that this is a relatively selective excerpt from "Current topics from the field of computer science and society". It might have made communication a little easier if, for example, we had discussed various topics from computer science and society at the first appointment in the break-out rooms instead of our abilities, because then everyone could talk about something instead of everyone about themselves (that may be easier for some).
Framing Constructive Communication	2	I am happy that this module outlined the importance of constructive communication – a trait which is easier described than demonstrated.
More time	2	It would have been better if we had maybe one more meeting for the project.
Not used to guilds	2	Between the teams, primarily in the guilds, chaos took over a little more at the beginning due to the larger number of participants and also because of the poor knowledge of the members.
Online discussion	2	In a way, the online meetings are both a blessing and a curse. On the one hand, they give you a feeling of anonymity and thus lower the threshold to say something, especially at the beginning. On the other hand, they also make the flow of conversation more difficult: bad connections prevent you from saying or understanding something, it quickly happens that everyone says something at the same time and then everyone pauses.
The way we worked improved my social skills	2	The way we worked together in these two sessions and between them helped me to overcome fear to speak in public, so I improved my social skills.
Tried best to overcome shortcomings inherent to online setting	2	However, the main thing that interfered with us in getting to know each other was the cause that we had online sessions. But generally, we got tried to do our best to overcome these difficulties.
A more organized Moodle page	2	One thing that comes to mind would probably be a more organized Moodle page. Although, this could just be me, since I dislike Moodle in general.

A tool for shared notes in breakout rooms	2	Some kind of tool for shared notes in the break-out rooms would still have been good, although there were "shared notes" in the rooms, but they were gone after the break-out session was over.
Active communication from both sides	2	Active communication from both sides is really the only thing that helps here.
An envoy to other guilds, when working in guilds	2	Maybe you could have made a few improvements to the task in the guilds, for example an "ambassador" to other guilds.

VI. DISCUSSION

A. Discussion of results

Quantitative findings show that students believed that this kind of self-organized teamwork was helpful in learning relevant content: 75% of students rated the support of content learning (Q1) on a scale from 0 (worst) to 10 (best) as 7 or higher. The median rating was 8 (with a standard deviation of 1.5). A few students shared that their social skills were advanced (2 mentions), particularly related to communication and teamwork (2 mentions), rather than broader societal topics related to Informatics.

RQ1: How can a university course be arranged to support self-organized online learning (SOOL)?

RQ1.1: What are the relevant factors in the frame of the course to enable SOOL?

Students pointed out quite clearly what helped or hindered their social interaction. The two most mentioned codes were the possibility to use "Breakout rooms" (21 mentions) and "Communication within the team worked very well" (both mentioned by 58% of the participants - 21 report mentions each). Since team communication during the course sessions was mainly possible in these breakout rooms, where they collaborated and self-organized without the presence of a lector, it can be concluded that breakout sessions were of very high relevance for SOOL in this setting. As one student stated regarding the breakout rooms: "How well this succeeds then eludes the course instructors and becomes the responsibility of the students themselves. It therefore depends on each individual how much you get involved in the given conversations and subsequently reveal yourself." This indicates that students did indeed feel "in charge of his/her own personal system of meanings" as intended by S-O-L [24], as well as in its online application SOOL.

Collaborating online, establishing and maintaining social contact appears more difficult: Course sessions end abruptly, and there are no informal meetings outside of the course structure. Many students (16 mentions) were concerned on how to maintain contact with their colleagues. Some observed that their familiar patterns of social interaction, such as establishing deeper personal contact between lectures, did not work in an online setting. One participant wrote: "It would have been nice if there was an easy way to get in touch with the people you met, after the duration of the course / breakout room, possibly through Moodle because often times different people attend different courses and once it is over you lose contact with them."

Different communication settings, within teams and across teams, drew rather differentiated responses. While participants generally agreed on being able to learn course contents through SOOL, 75% of the participants marked whether they could get in touch with fellow students easily on a scale from 0 (worst) to 10 (best) with 5 and above. The rating median was 8 (with a standard deviation of 2,5). From the qualitative content analysis, we can infer the following reasons for such variation: Students mentioned that they either would have liked to have more time in general (2 mentions) or more time in breakout rooms (9 mentions). Many students reported on the gained value in collaboration by turning on the microphone and the camera when working together (12 mentions). Students found it difficult when team members were not reachable during work sessions (3 mentions). Several students highlighted difficulties in collaborating online as opposed to meeting face-to-face (8 mentions). One student particularly reflects on the benefits and drawbacks of online conversation in a group (2 mentions): *"In a way, the online meetings are both a blessing and a curse. On the one hand, they give you a feeling of anonymity and thus lower the threshold to say something, especially at the beginning. On the other hand, they also make the conversation more difficult: bad connections prevent you from saying or understanding something, it quickly happens that everyone says something at the same time and then everyone pauses."*

Recurring work within the same team was considered as productive (7 mentions concerning work in small teams) and held with respectful communication by most of the students (21 mentions). One student stated with regard to teamwork: *"We gathered ideas together and always quickly came to an agreement"*. The more complex communication between teams on the other hand was often perceived as challenging (12 mentions). A student shared, for example: *"Communication worked well in my own group, but only moderately with the other groups. I find this format very difficult as it is often. There are 'leadership' problems. In each new group, a new interpersonal hierarchy always had to be found. But I found it very exciting here how quickly you have adapted yourself again and again. Once there was a 'leader' and another time everyone acted equally."* Students stated that they were not used to working in guilds (2 mentions). Yet, others pointed out benefits of meeting in guilds (7 mentions): *"In the session with people from the other groups, the discussion was surprisingly very sophisticated at the time, but then again, the discussion was between people who had proficiency in the same skill. It was engaging, and everyone was able to point some problems out in the document, and everyone was very open."* Other students shared that communication across teams worked well (3 mentions): *"At first, communication between the teams was faltering, but it has improved after groups were formed again according to specialty and each draft was checked again for errors."*

The warm-up phase to collaborative writing was considered worthwhile to get to know other students participating in the course (8 mentions). One participant shared a personal advantage of the online format: *"It was*

helpful to join in a random room in BreakOutRooms. In a small group, it was easier to overcome awkwardness and uncertainty." As the skills-self-attribution exercise was rarely mentioned, we assume students used it primarily as a communication anchor to get in contact with each other before forming teams on their own. Few students shared in their reports that they chose team members that they perceived as sympathetic (3 mentions).

RQ1.2: What infrastructure is necessary for successful SOOL?

Many students rated the infrastructure in place (Moodle as a knowledge base, Zoom for interactive sessions, a digital whiteboard for team building and GoogleDocs for collaborative writing) as a sufficient selection (11 mentions). The qualitative content analysis shows how some teams managed to mitigate hurdles in maintaining a continuous communication with rituals using freely available standard communication tools: *"For the small group assignment with the use of discord we arranged a meeting once in every week, which allowed us to keep track of where we stand in our assignment process. In those sessions, although not drastically, we get to know each other better."* Discord was frequently noted as a helpful tool to arrange meetings both during and outside the course (8 mentions). The emerging overall communication structure bears a resemblance to what has been called a dual-operating system in organizations [36]: a concept which describes a second informal communication structure beside the official communication channels. The online communication on Discord established by students on their own could be seen as such a second operating system that runs in parallel to the official Zoom calls.

B. Limitations

The findings outlined here apply to a specific context: undergraduate students of Computer Science. Therefore, we can assume that participants are familiar and comfortable with using information and communication technology for collaboration. The learning format has not yet been evaluated in other course contexts.

Researcher bias was identified by both authors. They have facilitated the epic bedtime story format several times previously in on-site higher education courses before implementing the format online. The first author also uses this approach in corporate business contexts. The results of the content analysis were sent to an expert auditor with experience in higher education course design in Computer Science who did not participate in the epic bedtime story setting nor in writing the paper. Suggestions regarding the integration of references to the paper, transparent description of the course setting and the presentation of results were considered.

The main goal of the entire course with the embedded epic bedtime story format is to support a reflective attitude of Computer Science students. How well the learning format enabled students to learn was evaluated from their own point of view as no tests were conducted in this course. Individual student reflections and teamwork products can thus not be

easily compared to more traditional learning formats with standardized tests.

Some student responses were translated by the authors.

VII. CONCLUSION

The questionnaire results and the students' strong participation throughout the course clearly indicate that they found this format helpful to learn course contents, and more so to get to know one another. Their differentiated answers to the questionnaire indicate that they also improved their online communication skills and their competencies in using online tools. SOOL appears to be a particularly supportive addition to the didactical toolbox during a pandemic, where online work is sometimes a must and social interaction often suffers. Compared with gamification learning approaches featuring sophisticated virtual reality environments like the crystal island experiment [26], the infrastructure prerequisites for an Epic Bedtime Story based course are far more affordable. What both approaches might have in common (and further research could follow-up on this hypotheses) that it creates a high level of involvement and motivation for students to achieve results on their own as teams. Benefits such as "self-efficacy, presence, interest, and perception of control" [28] are key goals in S-O-L. Therefore, we conclude that this approach is a promising and low-cost way to transfer the concepts of S-O-L to online learning.

Key factors to create a successful SOOL course include (1) an adequate communication design: the selection of a suitable gamification approach, and (2) an adequate balance of different communication settings: continuous work as teams in breakout sessions, where the teams can iteratively evolve their results, mixed with communication between teams. This communication design provides a *container* for self-organization to unfold, furthermore the chance for *exchange* as described in the CDE model. Regular reflections with some guidance from the lecturers can help the teams to identify relevant *differences* in their communication and to learn from them. For appropriate framing of such a course, it is further highly valuable to clearly state purpose and structural prerequisites (13 mentions "assignments clearer" 2 mentions in "alternative tool for less chaotic working together"). In an online context with shifting communication settings, this needs more careful preparation than when working in traditional online formats or in an onsite context.

From a perspective of S-O-L, communication settings should be "conversational learning environments that construct their own viability and validity, resulting in a capacity for creative and flexible thinking" [30]. Our qualitative content analysis shows that such conversational learning environments can successfully be constructed with the help of video conferencing tools and breakout sessions with small groups of seven people or less. As students pointed out, it is important that all participants have their video and microphone turned on and their attention is focused on the work within the group.

Social dynamics similar to those in onsite learning contexts could be observed (and maybe were accelerated by the online format), such as some students gaining the benefits

of a group session without contributing much and the irritation of others because of that.

It is helpful to encourage contact of the teams in between the lectures and propose means of doing so. How to maintain team contact was a topic raised by several students in their answers to the questionnaire.

Further application and evaluation of SOOL in other learning contexts can bring further insight. Particularly the question, whether the content of the course can be conveyed better through this learning format could not be answered through this research.

This effort seems worthwhile, as one student wrote: "*I have never expected that a lecture could be done in this manner. Despite the reality of a pandemic, we could interact with each other during the lecture.*"

ACKNOWLEDGMENT

We would particularly like to thank the students in this course for their openness and high engagement, Adaobi Onyenwe for auditing and Prof. Renate Motschnig for her unwavering support.

REFERENCES

- [1] C. Bock and S. Schilling, "Autokonzern steigt auf's Gas. Schwarmorganisation bei Daimler," *OrganisationsEntwicklung*, vol. 19/2, pp. 19-24, 2019.
- [2] K. Beck et al, "The agile manifesto", <http://agilemanifesto.org>, 2001
- [3] D. Haselberger and T. Spielhofer, "Privacy Guide Epic Development – Time-Constrained Distributed Team Work in an Undergraduate Higher Education Course on Informatics and Society," *Journal of Educational Multimedia and Hypermedia*, vol. 29, Number 3, July 2020
- [4] G. Eoyang, "Human systems dynamics: Toward a computational model," *AIP Conference Proceedings* 1479, 634, 2012
- [5] A. J. Magana, Y. Y. Seah, and P. Thomas, "Fostering cooperative learning with Scrum in a semi-capstone systems analysis and design course," *Journal of Information Systems Education*, vol. 29, no. 2, pp. 75–92, 2018.
- [6] A. R. Hulshult and T. C. Krehbiel, "Using Eight Agile Practices in an Online Course to Improve Student Learning and Team Project Quality," *Journal of Higher Education Theory and Practice*, vol. 19, no. 3, pp. 55–67, 2019.
- [7] V. Peñarroja, V. Orengo, A. Zornoza, and A. Hernández, "The effects of virtuality level on task-related collaborative behaviors: The mediating role of team trust," *Computers in Human Behavior*, vol. 29, no. 3, pp. 967–974, 2013.
- [8] I. Noguera, A.-E. Guerrero-Roldán, and R. Masó, "Collaborative agile learning in online environments: Strategies for improving team regulation and project management," *Computers & Education*, vol. 116, pp. 110–129, 2018.
- [9] N. Anderson, "Examining Ways COVID-19 Adaptation Derailed our Assumptions about Online Learning," presented at the 2020 IEEE Conference on e-Learning, e-Management and e-Services (IC3e), 2020, pp. 67–70.
- [10] [R. Y.-Y. Chan and Y. Zhang, "Collaborative Learning in Engineering Students under Social Distancing: An Action Research," presented at the 2020 IEEE Frontiers in Education Conference (FIE), 2020, pp. 1–5.
- [11] Z. Dvorakova and A. Kulachinskaya, "How the COVID-19 made universities switch to distance education: the Russian and Czech cases," presented at the Proceedings of the 2nd International Scientific Conference on Innovations in Digital Economy: SPBPU IDE-2020, 2020, pp. 1–7.

- [12] J. Zhu, "Directly Hit the COVID-19: Research on Online Education under 'Suspended Class, Ongoing Learning'," presented at the 2020 The 4th International Conference on Education and E-Learning, 2020, pp. 214-219.
- [13] A. Sun and X. Chen, "Online education and its effective practice: A research review.," *Journal of Information Technology Education*, vol. 15, 2016.
- [14] C. W. Nam, "The effects of trust and constructive controversy on student achievement and attitude in online cooperative learning environments," *Computers in Human Behavior*, vol. 37, pp. 237-248, 2014.
- [15] C. Coonradt, *The Game Of Work*, 1st edition, Gibbs Smith Layton, 1984, pp.6-7.
- [16] A. Krivitsky, *lego4scrum - one of the most interactive ways of introducing Agile thinking and Scrum framework*, 3rd edition, Leanpub, 2017
- [17] G. H  ther, *Mit Freude lernen - ein Leben lang*, Vandenhoeck & Ruprecht, 2016
- [18] E. Berne, *Games People Play: The Psychology of Human Relationships*, Grove Press, 1964
- [19] F.B. Simon, *Einf  hrung in die systemische Organisationstheorie*, Carl-Auer Verlag, 2010
- [20] J. Huizinga, *Homo Ludens, a study of the play element in culture*, Routledge & Kegan Paul, 1949 [Translated from *Homo ludens, proeve eener bepaling van het spel-element der cultuur*, Tjeenk Willink & Zoon N.V., Haarlem, 1938]
- [21] H. Lackner, T. Spielhofer, and K. Bareck, Karin, *Organizational Change through Games, orig: Organisationen spielerisch ver  ndern*, *Austrian Management Review*, vol. 9, 2019 pp.57-67
- [22] J. Mart  -Parre  o, E. M  ndez-Ib    ez and A. Alonso-Arroyo, "The use of gamification in education: a bibliometric and text mining analysis," *Journal of Computer Assisted Learning*, vol. 32, 2016, pp. 667 - 668
- [23] S. Park and S. Kim, "Patterns Among 754 Gamification Cases: Content Analysis for Gamification Development", *JMIR Serious Games*, vol. 6, iss. 4, 2018, pp. 2-16
- [24] D. Dicheva, C. Dichev, G. Agre and G. Angelova, "Gamification in Education: A Systematic Mapping Study," *Journal of Educational Technology & Society*, vol. 18, no. 3, 2015, pp. 75-88
- [25] L. A. Annetta & M.-T. Cheng, "Why Educational Video Games, From Theory to Practice," in *Serious Educational Games*, edited by L. A. Annetta, Sense Publishers, 2008, pp.1-12
- [26] J. P. Rowe, B. W. Mott, S. W. McQuiggan, J. L. Robison, S. Lee, J. C. Lester, "CRYSTAL ISLAND: A Narrative-Centered Learning Environment for Eighth Grade Microbiology", 14th International Conference on Artificial Intelligence in Education, Workshops Proceedings, 2009, pp.11-20
- [27] S. J. Coombs and I. D. Smith, "Designing a Self-Organized Conversational Learning Environment," *Educational Technology*, vol. 38, no. 3, 1998, pp. 17-28
- [28] L. Thomas and S. Harri-Augstein "A Conversational Framework for Self-Organised Learning," *Handbook of Conversation Design for Instructional Applications*, Centre for the Study of Human Learning, 2008, pp. 308 -342
- [29] N. Luhmann, *Organization and Decision*, Cambridge University Press, 2018, [Translated from *Organisation und Entscheidung*, 3rd ed., VS Verlag, 2011]
- [30] B. Williams and R. Hummelbrunner, *Systems Concepts in Action - A Practitioner's Toolkit*, Stanford University Press, 2010
- [31] S. De Shazer, *Putting Difference to Work*, W.W. Norton & Company, NY, London, 1991
- [32] C. Larman, Craig und B. Vodde, Bas, *Large-Scale Scrum More with LeSS*, Addison-Wesley, 2016
- [33] L. Adkins, *Coaching agile Teams*, Addison-Wesley, 2010
- [34] K. Schwaber and J. Sutherland, *The Scrum Guide The Definitive Guide to Scrum: The Rules of the Game*, 2020, <https://scrumguides.org/docs/scrumguide/v2020/2020-Scrum-Guide-US.pdf>
- [35] U. Kuckartz, *Qualitative Content Analysis. Methods, Practice, Computer-Support (orig.: Qualitative Inhaltsanalyse. Methoden, Praxis, Computerunterst  tzung)*. Weinheim und Basel: Beltz Juventa, 2018.
- [36] J. Kotter, *Accelerate*, Harvard Business Review Press, 2014