Testing Typical Challenges Affecting Idea Sharing in Distributed Design Teams Today

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Abstract

The aim of this study was to compare behaviours in distributed design teams today to the existing literature to see if previously identified challenges faced by distributed teams have been overcome. Recordings of teams' online idea sharing sessions were transcribed and split into idea sharing instances (units). A scoring system analysed the effectiveness of each unit. Having a clear structure with formal idea discussion, an assertive leader, and no time limits led to higher scores. Whilst instances of informal speaking and the wide variety of tools used had no link to the unit scores.

Keywords: design teams, distributed design, collaborative design, idea sharing, challenges of remote collaboration

1. Introduction

The aim of the study was to test previously identified challenges of idea sharing in today's distributed teams. The research question to be answered was: to what extent are the challenges affecting idea sharing in distributed design teams found in the literature still evident in a modern context? This is done by identifying communication behaviours present during modern online idea sharing and development meetings, and to establish which behaviours are beneficial to idea sharing and development and which are detrimental. This study utilised the unique situation of COVID-19 providing more exposure to distributed teamwork. The participants used in this study were student design teams working virtually on a product design project for their university course. The data collected were recordings of the teams' online idea sharing sessions. The recordings were transcribed and split into idea sharing instances which formed the units for analysis. To analyse the sessions and units, a scoring system was developed which would score the effectiveness of each idea sharing instance. Literature on effective communication in design teams was used to develop the scoring system.

2. Literature review to identify known challenges faced by distributed design teams

Looking at past research into challenges faced by remote design teams will help guide research relating to modern design teams. Previous research reveals several themes in the types of challenges that virtual teams face. It is noted that whilst many of these challenges are not unique to virtual teams, they are exacerbated in virtual teams compared with face-to-face teams (Berry, 2011).

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Building Trust

This issue is the most universally presented in all research reviewed in this section. Virtual teams having difficulties engaging in informal and social communication as a team is noted in literature by Berry (2011), Rosen et al. (2007), and Brewer (2015). Following directly from the challenge of engaging socially, are difficulties building trust and establishing a rapport between members due to a lack of comfort within distributed teams (Rosen et al., 2007; Brewer, 2015; Kirkman et al., 2002). This also relates to another issue pointed out by Kirkman et al. (2002) that members of distributed teams may struggle with feelings of isolation due to being detached from other team members. An added problem with these difficulties is noted by Sosa and Eppinger (2002) in a study of information exchanges in distributed product development teams. They found that other negative impacts of design teams being distributed can be combated by a high degree of interdependence. Therefore, whilst it is difficult for distributed teams to build trust and a rapport, it is essential for overcoming other challenges.

Sharing Information

Developing a shared understanding is important for the performance of any design team (Cash et al, 2017), whether in person or distributed. It is noted that achieving this is more difficult in distributed teams (Berry, 2011). It is more difficult to balance technical and personal skills and coordinate different perspectives of members within distributed teams (Berry, 2011; Kirkman et al., 2002). Sharing information is also impacted by the challenges of distributed teams that Brewer (2015) noted: information being incomplete, missing, conflicting, or unrelated and unnecessary, assumptions made by members being inaccurate, and a lack of clear detail being shared. Rosen et al. (2007) also noted that distributed teams have more difficulties keeping members' attention during information sharing due to local demands and distractions individuals may have.

The Use of Technology

Whilst the use of computer-mediated technology is not a characteristic unique to, or a requirement of distributed teams, it is a characteristic typical of distributed teams (Berry, 2011). Like building trust, the use of communication technologies can combat other negative impacts of a team being distributed (Sosa & Eppinger, 2002). However, members of distributed teams must learn to understand the communication patterns of other team members and adapt to them (Brewer, 2015). The team as a whole must also establish a shared expectation of the technology they choose to use (Brewer, 2015). Suchan (2001) found that approaching the technology used to communicate with the correct mindset allowed members to be creative and complete tasks whilst maintaining relationships. These are challenges that are much less prevalent in face-to-face teams.

Leadership and Organisation

Brewer (2015) found a particular issue for distributed teams is establishing clear boundaries and identifying leadership roles within the team. Needing clear leadership also relates to Kirkman et al.'s (2002) findings that having recognition for distributed teams' performance is key to a team's success. Sosa and Eppinger (2002) have also noted that it is important for distributed teams to have strong organisational bonds. It would follow naturally from the challenges of gaining trust and sharing information that it would both be more difficult to establish leadership and be important to have formal organisation within a team.

3. Methodology

The method for the study was to: develop a session scoring system to judge which sessions were most effective in terms of idea sharing; score the sessions using the developed scoring system; then study specific behaviours of interest within each session; and finally compare those behaviours and scores to find which behaviours are beneficial or detrimental.

3.1. Data Collection and Processing

Three groups in their third academic year (following two academic years and a year working in industry) of an Integrated Design Engineering degree at The University of Bath participated in the study. The groups (of 6 or 7 members) contain an even mix of students' previous academic abilities to ensure motivation and drive is equivalent. No account of cultural background is made as students are several years into their degree at this point. The study is conducted during their Group Business and Design Project. In this full-time 4-month project, students work for an industrial client on a real project. Students autonomously manage the design process for their own project, with some variance in when idea sharing sessions are most needed (some teams can start generating solutions from the beginning, whilst other teams need first to define the design opportunity itself). The participants had control over recording their meetings and sent the data to the researcher afterwards. Participants were asked to record meetings at various stages over the first 8 weeks of their project. The aim was to obtain at least 2 recordings from each group. In total 8 recordings were obtained of idea sharing and development, all of which were analysed. Transcripts of the recordings were generated using Microsoft Streams' auto-captioning tool, then manually corrected by the researcher to create protocols for analysis. The transcripts were then parsed into units for analysis that were individually scored.

One unit of analysis consisted of one idea sharing instance and any discussion which followed. A unit started with the first comment which suggests starting or moving onto a new idea. For example, "shall we move on?", "let's look at this idea now", "my idea is next". A unit ended with the last comment referring to that idea. Some sections of the recordings were not included in the units of analysis. Typically, this was the introduction of the meeting and conclusion at the end. These sections were still reviewed by the researcher. On average each recording was split into 5 units with a total of 44 units across 8 recordings.

3.2. Developing the idea-sharing session scoring system

Previous research was examined for potential ways to score idea sharing and development. In the literature, various ways of measuring successful communication are presented. Question asking and feedback is a key antecedent for shared understanding (Cash et al., 2017; Qu & Hansen, 2008). Studies by Stempfle and BadkeSchaub (2002), and Qu and Hansen (2008) show the process of developing a shared understanding involves question asking as a critical stage. Therefore, effective idea sharing and development should include multiple instances of question asking. Stempfle and BadkeSchaub (2002), and Qu and Hansen (2008) also state that the evaluation of ideas is a key part of the process of developing a shared understanding. This allows teams to deal with potential design problems. Dong (2007) and Sonalkar's (2012) studies looked at language in the design process and found appraisal and evaluation of ideas were key operators in the design process. Alnuaimi et al. (2010) and Shah and Vargas-Hernandez (2003) evaluated design teams' effectiveness using the number of unique ideas the teams generated. This was particularly relevant for distributed teams as they found that social loafing tended to be higher in distributed teams than face to face, meaning individuals withheld contributions more in distributed team settings. Dong (2007) also found that accumulation, the building upon ideas and concepts, is a key performative operator in the design process. Several studies have identified that better and more creative ideas are highly linked to other ideas (Goldschmidt & Tatsa, 2005; Van der Lugt, 2005; Hatcher et al., 2018). Other studies expand on this by differentiating different types of links between ideas: self or interpersonal, and parallel and tangential (Van der Lugt, 2005; Hatcher et al., 2018). More interpersonal and tangential links[1] to ideas indicates a more collaborative and creative design process (Hatcher et al., 2018). This research suggests that perhaps better idea sharing leads to more ideas being developed by other participants.

Following the initial review of the recordings and the above analysis of the literature, the four categories were selected for the scoring system shown in (Table 1): Number of questions asked; Number of new ideas generated; Number of comments made (Idea evaluation); and the Number of topics debated (Idea discussion). Each category was scored then the total score for each unit (idea sharing instance) was added up. Using suggestions from Blessing and Chakrabarti's research methodology (2009), a scale was

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[1] In these studies, tangential links typically refer to links between ideas where themes or contexts do persist, but ideas go off in new direction.

developed from 0-3 for each of the four categories. Generally, the meaning of the scores are: 0 = None; 1 = Low; 2 = Medium; 3 = High. Then the data was visited and revisited iteratively to fine tune the scoring system for each category. Instructions were written for how to score the data, defining what should be included in each count. These definitions were refined during reliability tests, eventually resulting in an 85% agreement rate from a second observer looking at samples of the data which covered more than 10% of the data set. To enable analysis at the session level, the units (idea sharing instances) are averaged to create a 'session score' to allow comparisons between sessions.

Table 1. Category counts and associated scores applied at the 'idea sharing' unit level

Category	Count	Score
Number of Questions Asked: Any question relating to an idea and its development was counted. Questions can be asking for clarification or asking another participant to share their ideas. *'... How does it work? Does it? Absorbs the impact and does not transmit the force to the internal objects?...'*	0	0
	1-3	1
	4-6	2
	7+	3
Number of New ideas suggested: Any new idea proposed after the initial idea is shared in each unit is counted. An idea can be an adaptation of the original idea or a completely different idea. *' ...I was wondering, sorry, I was wondering if you could have like an almost like a detachable tablet...'*	0	0
	1-2	1
	3-4	2
	5+	3
Number of comments made about the ideas: Any positive or negative point about an idea is counted. *' Although I do like the idea of the management system that....' or ' ...Yeah, that's cool...'*	0	0
	1-3	1
	4-6	2
	7+	3
Number of issues debated about the ideas: Debate topics are counted following a count of comments. *'...It would be it would be perfectly reasonable if it was cheaper than...'*	0	0
	1	1
	2-3	2
	4+	3

3.3. Choosing which characteristics to study

Typical challenges affecting idea sharing in distributed design teams identified in the literature included: informal speaking and social communication; keeping attention; leadership roles; team organisation; and technology usage. Following the initial review of the data it would be possible to make behavioural observations under headings such as these: stage of design process; circumstances of the design session; ending of the session; structure of the session; planned time limits; leadership role and group dynamics; instances of informal speaking including casual off-topic conversation and instances of humour; platform used; camera usage; tools used; attention to screen; internet issues; etc. The specific characteristics within each session reported on in this paper (presented below) were selected based on whether they have previously been discussed in the literature. This would help us compare challenges of idea sharing in distributed teams that are presented in the literature with what is going on in distributed design teams today.

Session-Level Characteristics (characteristics compared to the session scores)

- Structure and Time Limits: To review team organisation and the communication of clear boundaries, how the sessions were structured to share and discuss ideas is noted, including how strict the structures were and any imposed time limits.
- Leadership roles and group dynamics: Again, to review team organisation and communication of clear boundaries, notes were taken on leadership in the sessions and how much the leader dictated the structure and flow of the sessions, along with each participant's contribution to the session.
- Instances of Informal Speaking: To review social communication and informal speaking, conversations unrelated to the project, instances of humour, and any games played were noted.

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Idea-Level Characteristics (characteristics compared to the unit scores)

- Tools used: reviewing the use of technology, any computer-mediated tools used during the unit were noted, including screen sharing and virtual whiteboards. The platform used to host the meeting, if cameras were on, and how much they were used was noted.

4. Results

In total eight useful recordings were collected from three teams, parsed into 44 units of idea sharing instances (units) for analysis. All units were given a score between 0 and 3 for questions, new ideas, comments, and debate. The four scores were then summed to give a total unit score between 0 and 12. The average unit score for each session was calculated and is displayed in (Table 2). There is good variation in the session scores with the lowest score 3.875, and highest 8.

Table 2. Session scores created from the average unit scores within each session

Recording, units	Score	Recording	Score
Group 3, Session 1	3.67	Group 2, Session 3	5
Group 1, Session 2	3.875	Group 2, Session 2	5.75
Group 1, Session 1	4	Group 3, Session 2	7
Group 2, Session 1	4.25	Group 3, Session 3	8

4.1. Structure of Session and Time Limits

The structure of each session varies. Sessions can be differentiated between that where discussion was formally introduced or if discussion only occurred if it came up naturally. There is a clear link, shown in (Figure 1) (left), that the structured sessions with formal discussion had higher scores than those without.
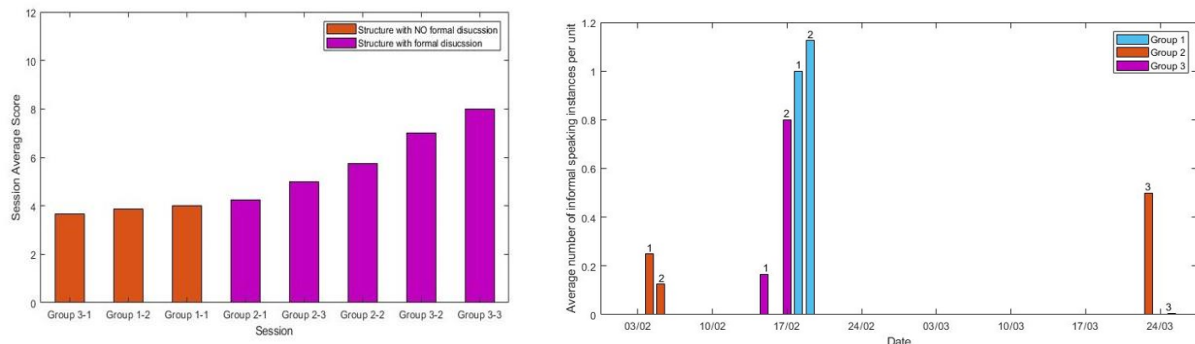
Figure 1. (left) Session average unit score with or without formal discussion, (right) Average number of instances of informal speaking per unit plotted against date

In group 2 session 2, the participant leading the session sets out clear rules for the discussion, which include "no straight negativity or criticism". Dictating no negative comments could have led to a less rich discussion and a lower score. However, the average score for this session was 5.75, the third highest. It is also higher than both of the other group 2 sessions which had scores of 4.25 and 5 suggesting that, for group 2, having formal guidelines for the discussion lead to better idea sharing and development. The higher score could also be a result of the rule for discussion that concerns should be "suggesting a way that an already great design can be improved upon".   Group 2 session 2 was also the only session where the method used to share ideas was dictated by the participant leading the session. The participants were asked specifically to draw their ideas onto the MIRO board they were using. Whilst this does not appear to have affected the sessions' average score, several comments were made by participants that they found drawing their ideas difficult or that their drawings were not very good (e.g. quote from articant D: '…Cool, yeah, I'm next. I didn't draw anything 'cause I didn't want to draw…')).

No session had a strict time limit for the entire session. Both group 1's sessions needed to finish before another meeting, but this allowed over four and half hours and they finished over half an hour before

this deadline. Both sessions had low scores, with only one other session lower. (Table 3) summarises the time limits imposed on each session. Four sessions had short time limits for the initial activity of coming up with ideas or for adding ideas to a shared space. No group imposed a time limit on the discussion portion of the meeting. Group 3 sessions 2 and 3 were the only sessions with no time limits imposed and they also had the highest average session scores suggesting not imposing time limits is beneficial. However, in most cases, where time limits were imposed, the leading participant asked if more time was needed, and in all cases, where it was requested, more time was granted. This is discussed more in the next section.

Table 3. Summary of session time limits

Recording	Actual session time	Time limits imposed on each session	Score
Group 1, Session 1	01:09:51	Around 4.5 hours whole session	4
Group 1, Session 2	01:57:00	Around 3 hours whole session	3.875
Group 2, Session 1	00:57:22	5 minutes for writing initial ideas	4.25
Group 2, Session 2	01:38:31	5 minutes for adding drawings to MIRO board.	5.75
Group 2, Session 3	01:09:06	20 minutes to do activity, then unlimited for discussion.	5
Group 3, Session 1	01:49:48	20 minutes for SCAMPER activity.	3.67
Group 3, Session 2	01:20:21	None	7
Group 3, Session 3	00:13:15	None	8

4.2. Leadership Roles and Group Dynamics

All sessions had one participant who led the session to some extent. The leader varied within the groups and was not always the project manager. There was significant variation in how much the structure of the idea sharing and discussion was dictated by the session leader. In group 2 sessions 2 and 3, the lead participant very clearly dictated the structure. In session 2, the leader dictated that the participants should draw ideas and in session 3, the leader dictated a very clear activity (SCAMPER) to develop new ideas. In both sessions, participants were not asked for opinions or feedback on the proposed structure before starting. Although in session 2, the project manager approves the propose structure and participants were asked if they were happy with the 5-minute time limit (example transcript shown in Table 4) and if they needed more time at the end of the 5 minutes. In session 3, although not asked for feedback, several of the participants made comments that they liked the activity the leader dictated.

Table 4. Group 2, Session 2, excerpt highlighting agreement of time limits

Time		Transcript
	B	…Um so. I think are you guys? Do you guys think a 2, 5-minute sessions would work? Or would you prefer slightly longer sessions? Or should we just start and see how it goes?
00:04:28	E	Yeah start, let's see what happens.
00:04:30	A	I think. Yeah, I think if at the end of the five minutes we need more time, we can just had another 5 minutes.

In group 3 session 2, one participant leads and dictates the structure however the groups are explicitly asked for feedback on the proposed structure (Table 16). In group 3 session 3, only one idea is presented and the participant presenting generally leads but no structure is dictated. Group 3 session 1, also has a clear leader but the group was asked for suggestions on how to change the structure dictated by the leader. Whilst the leader proposed the structure, they did not actively move the group through the session without consent from all the participants. This is also true of both group 1's sessions which were generally led by the project manager but there was no dictation of structure during the meeting, and the session did not move onto new stages without approval from all participants. All sessions did have some sort of leader, which does shows that assigning leadership roles was not an issue in the remote session. The three sessions which had the least dictation from the leader were also the three with the lowest average scores. (Table 5) shows the observations of leadership and group dynamics for these sessions. Therefore, having clear and assertive leadership is desirable in idea sharing meetings.

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Table 5. Sample of leadership roles and group dynamics observations

Recording	Structure	Score
Group 1, Session 1	PM (A) Generally leads meeting. Everyone agrees before moving onto next idea. No dictation how to present idea.	4
Group 1, Session 2	PM (A) Generally leads meeting. Everyone agrees before moving onto next idea. No dictation how to present idea.	3.875
Group 3, Session 1	A (PM) Generally leads meeting. They selected all the prompts but asks if anyone wants different prompts. Agreement from all members before moving on.	3.67

4.3. Informal Speaking

(Figure 1) (right) shows that the earliest sessions, both occurring in week 1, had less social communication and informal speaking (unrelated conversations, instances of humour, or games played). Session 3 from the same team has a significant increase in instances of informal speaking and occurs 7 weeks later. It was also noted that the third session generally had a much more relaxed atmosphere than the two earlier sessions. It is consistent with the literature that earlier sessions would have fewer instances of informal speaking as trust within a group needs time to build. Group 3 was the only group to do a warmup activity (playing a game) in sessions 1 and 2 which happened early in the project timeline (week 3). The group did not do a warmup activity in session 3, perhaps because only one idea was being shared or because the session took place much later in the project, so trust had already been built. Group 3 session 2 occurred two days after session 1 and had more instances of informal speaking (sample in Table 6).

Overall, there is no direct link between number of instances of informal speaking (figure 1 - right) and overall session score (Table 2). The sessions with more instances of informal speaking are also the sessions which had a less formal structure and no clear leader as discussed previously in sections 4.2. Later sessions generally had more instance of informal speaking. However, all sessions (apart from group 3 session 3 with only one unit) had at least one instance of informal speaking, suggesting that distributed teams can have this type of communication even at early stages.

However, when looking in detail at the scores for each idea sharing unit (data not shown here but meaning: the Number of questions asked; Number of new ideas generated; Number of comments made; and the Number of topics debated) there was a pattern showing that social communication and informal speaking led to more questions being asked and more comments being made. There was no link between informal speaking and ideas generated and number of topics debated.

Table 6. Samples of instances of informal speaking from one of the sessions

Recording	Structure	Score
Group 3, Session 2	Session starts with a game to warm up. UNIT 1 – 00:21:00 – 'Ah it's a fix, a fix, you knew that before…' Laughter at joke from E that B already knew about their topic. UNIT 2 – …. UNIT 3 – …. UNIT 4 – 00:58:08 –Laughter at C's comment 'I am loving the idea of armour plating inside of leotards. I think that's very necessary…'. UNIT 5 – 00:55:58 –Laughter when A mentions that idea is from a movie 'I remember a Mission Impossible movie where they did this…'. 00:59:18 –Laughter at E's comment 'Ready to conquer Mars when it's colonised?'.	7

4.4. Tools Used

In all sessions, a Microsoft Teams video call was used to host the meeting. This platform was readily available to the participants as the university had set up channels for each group and encouraged them to use it. As well as hosting meetings and text chat, Microsoft teams also allows groups to share files and collaboratively make changes in real time.

Presentations

Group 1's sessions were more formally led, as shown in (Table 1).. To share each idea, the participants had created presentations using a variety of software: Microsoft PowerPoint, Apple Keynote, Google

Slides, and Microsoft OneNote. The presentations were then shared with the group via screen share on the video call. Several of the presentations had been created by multiple participants collaboratively. This was achieved either by PowerPoint uploaded in Microsoft Teams or using Google Slides, both of which allow live collaborative working on the document.

Computer Aided Design (CAD)

Group 3 session 3 was also a more formal session, in which, participant F who was presenting their idea, used screen sharing to show CAD models they had completed of concepts, directly from the AUTODESK inventor CAD program.

Virtual Whiteboards

Both Groups 2 and 3 made use of MIRO whiteboards. This is a virtual whiteboard software which remote users can simultaneously access, view, and add to. The MIRO board does not need to be screen shared as every participant can view it on their own devices and can see updates to the board live as they happen. For example, in group 2 session 2, participant E was able to draw live whilst asking a question, to illustrate what they were asking. In all sessions one participant screen shared their view of the MIRO board so that it would be seen on the recording. Both groups used the MIRO boards to add sketches of ideas, text explaining ideas, pictures from the internet, and post-it notes adding detail. In group 2 session 2, all ideas were drawn onto the MIRO board. Participants with tablets and a drawing stylus could draw directly onto the board. The others who did not have this facility drew onto paper and uploaded photographs of the drawings onto the MIRO board. In sessions where the method was not prescribed by the session leader, participants used different ways of presenting their ideas on the MIRO board. As discussed in section 4.1, some participants preferred to not draw on the board and opted for text, post-it notes, and images from the internet. The tools used changed with how formal the sessions were.

A common feature with all tools chosen was that all participants were able to view the content being presented live either through a screen share or a tool which allowed simultaneous working. In all sessions apart from group 2 session 2, the groups allowed individual participants the flexibility to choose their preferred tool or preferred method to utilise the tool. For example, Group 1, all used some form of presentation, but across 10 ideas, they used 4 different platforms to make them. There is no link between tools used in each unit and overall score. (Table 7) summarises the highest and lowest scoring idea sharing units for each tool used. Presentations and MIRO boards were associated with both high and low scores, and the one example of screen sharing CAD had a medium score. The variation in MIRO board scores was also not associated with how the board was used with uploads of hand drawings receiving both high and low scores, as did internet pictures, typed notes, and using a mouse as a pointer on the board. Whilst there is no link between specific tools used and scores for idea sharing and development, it is notable that the groups did not struggle to use the tools. This may have been because they had been introduced to the tools before starting the project.

Table 7. Summary of tools used in highest and lowest scoring units

Recording	UNIT	Structure	Score
Group 1, Session 2	3	PowerPoint presentation.	9
	5	PowerPoint presentation.	2
	7	PowerPoint presentation.	0
Group 2, Session 2	7	MIRO board; Photos of hand drawings uploaded.	9
Group 2, Session 3	6	MIRO board; Photos of hand drawings uploaded; Mouse as pointer.	2
Group 3, Session 1	3	MIRO board; Drawings directly on board; Internet pictures; Typed notes.	2
	4	MIRO board; Drawings directly on board; Typed notes.	2
Group 3, Session 2	2	MIRO board; Photos of hand drawings uploaded; Typed notes.	9
	5	MIRO board; Internet pictures; Typed notes; Mouse as pointer.	12
Group 3, Session 3	1	PowerPoint presentation; AUTODESK inventor CAD model – screen shared; Mouse as pointer.	8

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5. Discussion

This section summarises the answers to the research question: to what extent are the challenges affecting idea sharing distributed design teams found in the literature still evident in a modern context? The study takes advantage of the teams having worked remotely for 10 months due to the COVID-19 pandemic giving them a unique amount of experience and exposure to completing design work remotely. Four challenges of working in distributed design teams were identified from the literature. These were reviewed in this study and the results of the study are discussed below.

Structure and Time Limits

Contrasting with the literature, this challenge was not present in the results, with all sessions following a clear structure and no team struggled with organisation. However, as is the case with leadership roles, the results are in line with the literature's statement that having more organisation and structure is beneficial.

Leadership roles and group dynamics

All sessions had a single leader but there was significant variation in how assertive the leader was in dictating the meeting structure and progress. The results showed that having a more assertive leader is desirable. From the literature (Brewer, 2015), it was expected that the distributed teams would find assigning leadership roles to be more difficult. This does not seem to have been a challenge in this study. However, the results are consistent with the literature in that having an assertive leader was shown to be beneficial.

Informal Speaking and Social Communication

The results found were consistent with the literature in that instances of informal speaking and humour increase in later sessions. However, the literature indicated that building trust (Rosen et al., 2007; Brewer, 2015; Kirkman et al., 2002) and establishing informal and social communication (Brewer, 2015) is challenging for distributed teams. This was not the case in this study as all groups had some instances of informal speaking. However, this would need to be compared directly with face-to-face teams to see if it was more difficult in distributed teams or vice-versa.

Tools Used

Very few issues with internet connection were noted and participants had no issues using computer-mediated tools. The groups utilised various tools, all of which could be adapted to individual participants' preferences and to fit the circumstances of the session. This indicates modern technology is more flexible than is suggested in the literature (Berry, 2011; Sosa & Eppinger, 2002). The literature mostly focused on older, text-based tools such as email. This study addressed this issue with participants using conferencing platforms and live collaboration tools. The study is limited by the selection of tools the participants used and a direct comparison would need to be made to more traditional tools used in a face-to-face setting in a controlled experiment.

6. Conclusion

Overall, the four challenges distributed design teams faced for idea sharing identified from the literature, were not found to be challenges in this study. The literature is perhaps not keeping up with the pace of change in practice of modern distributed teams. This study was conducted in an entirely unique situation: the participants had already been working partially or entirely remotely for 10 months at the beginning of the project because of the COVID-19 pandemic. The participants had also been trained in methods for working as a remote design team including introductions to the tools they utilised. This allowed them to select the tools that were most suited to aid them in their idea sharing and discussion sessions. The research has shown that typical challenges affecting distributed design teams are overcome when the design teams have had appropriate training and exposure to designing virtually and make use of appropriate modern collaborative design tools.

One limitation of this study is that the results can only be compared to the literature no direct comparisons to face-to-face teams have been made. To improve the methodology further, time could have been considered by: either including a time efficiency score for the units; or a unit/time rate. Another limitation is that no direct comparisons have been made to industry settings. However, we would expect that design teams in industry, during this period, will also have been introduced to new collaboration tools and adopted them. The final limitation worth mentioning, is that participants were in full control over recording the meetings and decided when to start and stop the recordings. Whilst this helped ensure the study remained natural and realistic, it is possible that important sessions or sections of sessions may have been missed.

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