CREATIVITY IN A 24H-LONG VIRTUAL DESIGN TEAM

Complete Research

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Abstract

Creativity has traditionally constituted an important topic in organizations and its importance seems to have increased as we have been moving from traditional, physically collocated to virtual, geographically dispersed team configurations. Our study aims to bridge this gap by examining the case of creativity in virtual design teams (VDTs)—that is, virtual teams in the context of engineering design. We see design as a collaborative activity and use it as the empirical context in this study. We report on the findings from a case study with a temporary, 24h-long, VDT, which examined the relationship between creativity and virtuality. We employed multiple data collection methods, capturing most of the 24h, (i.e. interviews, non-participant observation, videos, design outputs, written communications), and analysed our data thematically following an interpretive approach and by using the 'team' as our unit of analysis. Our study extends prior knowledge on creativity in virtual teams by (a) positioning creativity within the VDT lifecycle; and by (b) elucidating the relationship between creativity and the unique characteristics of virtuality. We infer that boundaries, language, geographical dispersion, subgrouping, and computer-mediated communication are associated with creativity in the VDT context; and explain how they influence it.

Keywords: virtual design teams, creativity, globally distributed teams, design collaboration.

1 Introduction

With the information systems (IS) literature having paid considerable attention to the rather ubiquitous phenomenon of virtual teaming within and beyond organizations over the last decade or so (Panteli, 2009), it is time to elucidate how creativity develops in a virtual team (VT) environment (Martins and Shalley, 2011, Nemiro, 2007, Ocker, 2005). Current scholarship has addressed a number of challenges encountered in VTs, where most of the work is accomplished via computer-mediated communication (CMC), yet very few studies have explicitly looked into creativity in virtual teams thus far. For example, trust constitutes an extensively discussed issue in the VT literature. Studies on trust have shown that trust in VTs cannot develop following similar practices as in traditional teams. Creativity, which is generally associated with the generation of new ideas (Amabile, 1988), has not been adequately investigated in the VT environment. Though, for instance, a number of factors have been found to influence creativity in VTs, it is not clear how virtuality *per se* influences creativity or how these relate to the VT lifecycle. Our study therefore aims to address these gaps, assuming that the unique characteristics of virtuality exert an influence on creativity in this context.

We selected engineering design as the empirical context of this study because designers often work in VTs, or virtual design teams (VDTs), as we will refer to them here, and their work requires creativity. We conducted a case study with a temporary VDT comprising ten student engineers, half of whom were based in France and the rest in the UK. The students partook in a popular within the design community project, known as the 'ESTIA 24h of Innovation' (henceforth shortened to ESTIA24), which is unique in that the participating teams are assigned an engineering design task to be accomplished within 24h, enabling the researchers involved to observe the project from start to end. We employed multiple data collection methods and our data were analysed quantitatively and qualitatively. Our findings contribute useful accounts explaining how virtuality influences creativity in this particular VDT context advancing relevant IS literature, and may also be of value to the creativity and design communities.

The remainder of this paper is organized as follows: First we introduce the conceptual foundations of our study, namely VTs and creativity. Subsequently, we present our research site, methods and findings, and discuss our study's contributions, limitations, and implications.

2 Conceptual Foundations

2.1.1 Virtual Teams

The IS and organizational literatures agree that VTs comprise members that work on a common goal from distant locations predominantly via CMC channels (Cascio, 2000, Kayworth and Leidner, 2000, Lipnack and Stamps, 1997). Therefore, their most salient characteristics are geographical separation/dispersion and relative lack of face-to-face (F2F) communication; overcome with CMC. VTs emerged as a response to a highly competitive global business environment, wherein organizations are expected to capitalize on global expertise, cross-cultural collaboration, and time differences (Cascio, 2000). Further, however, to the aforementioned salient characteristics, and potential benefits, of VTs, there also exist latent characteristics pertaining to VTs, which raise unprecedented challenges for their management.

For example, oftentimes participation in a VT entails (a) having no work or other history with the rest of the team; (b) working in different time zones; and (c) being part of a highly diverse team. In fact, it has been asserted that VTs are multidimensional, as they may be (a) inter- or intra-organizational (organization-related); (b) global or local (location-related); and (c) temporary or permanent (time-related) (Panteli, 2004b). Another type of VTs is that of Partially Distributed Teams (PDTs) (Ocker *et al.*, 2009), comprising two or more physically collocated subgroups. Such subgroups may influence the performance levels and team dynamics of VTs significantly (O'Leary and Mortensen, 2010, Panteli and Davison, 2005). Moreover, not all VTs make use of similar Information and Communication Technologies (ICTs); CMC in VTs can vary from completely asynchronous (e.g. email) to synchronous (e.g. videoconferencing (VC)), exhibiting varying levels of communication richness (Dennis and Kinney, 1998). What is more, the VT lifecycle is different to a traditional team's; for example, Hertel *et al.* (2005) find that the lifecycle of a VT comprises the following phases: preparations (e.g. technology, participants); launch (e.g. development of rules); performance management (e.g. performance/knowledge management); team development (e.g. training, evaluation); and disbanding (e.g. recognition of achievements).

Not all VT configurations are the same, as they might differ in several aspects, including duration, ICTs used, and degree of geographical dispersion, making their management a challenging task. More recently, given that it is not uncommon nowadays for VT members to meet F2F, scholars have begun to talk about virtuality in teams, rather than VTs, purporting that all teams are virtual to some extent. Despite such assertions, our earlier discussion shows that there exist a number of characteristics which render VTs different from traditional teams. We call these unique characteristics of virtuality and argue that, as we have seen with trust (DeRosa *et al.*, 2004, Jarvenpaa *et al.*, 1998, Panteli and

Duncan, 2004) and leadership (Bell and Kozlowski, 2002, Cascio and Shurygailo, 2003, Zigurs, 2003), and other topics too, these characteristics may exert an influence on creativity in a VT environment. This takes us to the next section, where we discuss the topic of creativity, before highlighting its importance in the context of VTs in 2.1.3.

2.1.2 Creativity

Creativity is the precursor for innovation, constitutes an important topic in organizations and is a topic of cross-disciplinary importance (Amabile, 1988). With time, its importance seems to have increased, as creativity is viewed as the means for developing a competitive advantage in a highly competitive global business arena (Andriopoulos and Dawson, 2009). Creativity typically refers to the generation of ideas that are both novel and useful in a particular situation (Amabile, 1988). Early creativity literature centred on the individual, arguing it is certain cognitive abilities (e.g. ability to synthesize) and personality traits (e.g. originality in thinking) that lead to expression of creative behaviour (Guilford, 1950, Torrance, 1974). This research (Torrance, 1974) also contributed ways to measure the degree to which individuals may possess abilities that can lead to creativity. Further to these abilities, scholars have also found that relevant knowledge and motivation constitute factors influencing creativity at the individual level (Amabile, 1988). Later studies, however, took a focus on the team and organizational levels of creativity, asserting that such factors as leadership, team composition, heterogeneity, organizational culture and technology may also exert an influence on creativity (Bharadwaj and Menon, 2000, Chen, 2006, Fagan, 2004, Magadley and Birdi, 2009, Mumford *et al.*, 2007, Pearsall *et al.*, 2008, West, 1990). Further to these factor-based studies, creativity has also been viewed as a process in the literature. For example, Lubart (2001) conducted a review on the creative process, and argued that the traditional, consisting of four stages (preparation, incubation, illumination, verification), creative process model has been, and will have to be again, revisited, after carefully considering the subprocesses one (individual/team) follows.

We argue that this research has yielded some useful insights into how creativity can develop either by individuals themselves, or within a team or organizational environment, but there is no evidence about how creativity manifests itself in a virtual environment. Investigating this is important because of the increasing popularity and deployment of VTs in a number of fields, including engineering. For this, it becomes critical to review the extant literature pertaining to creativity in VTs.

2.1.3 Creativity in Virtual Teams: What do we know?

The study of creativity in virtual settings traces its roots back in the 90's when researchers became concerned with idea generation in CMC environments of that epoch (Aiken and Vanjani, 1997, Sosik *et al.*, 1998, Valacich *et al.*, 1994a, Valacich *et al.*, 1994b). More work followed on this topic, which explored (a) the divergent and convergent aspects of idea generation in CMC teams (Kerr and Murthy, 2004); (b) ICTs seen as pertinent for idea generation (Ardaiz-Villanueva *et al.*, 2011, DeRosa *et al.*, 2007); (c) e-brainstorming (Alnuaimi *et al.*, 2009, Murthy, 2009); (d) the idea generation process (Lilien *et al.*, 2002); and (e) the effects of anonymity ensued by CMC on idea generation (Pissarra and Jesuino, 2005). These studies pursue a better understanding of how creativity develops in CMC environments, but carry the following limitations: (a) they ignore the implications of being a VT member as discussed earlier; (b) they focus on idea generation only and do not talk about creativity; and (c) some of them refer to ICTs that are not relevant today.

More recently, scholars have talked about creativity in VTs more explicitly. For example, Nemiro mapped out the VT creative process (Nemiro, 2002), following a four-stage model, similar to the one in the traditional literature (see above Lubart, 2001); and identified a number of building blocks (e.g. interpersonal and task connection) that need to be in place for creativity to occur (Nemiro, 2007), while Ocker (2005), on the other hand, unpacked a set of enhancers (e.g. stimulating members) of and inhibitors (e.g. dominance) to VT creativity. Furthermore, Kratzer *et al.* (2006) infer that the higher

the variance of geographical dispersion and computer mediation, the more creative the VT performance in terms of generation of ideas, application, and methods. Further research on the topic has looked into anonymity and structure for VT creativity (Chang, 2011); the effects of member demographic variations on VT creativity (Martins and Shalley, 2011); the associations between leadership style and VT creativity (Wang *et al.*, 2011); and finally brainstorming in VTs (Dzindolet *et al.*, 2012). However, in most of these studies the role of virtuality and its unique characteristics has been significantly downplayed. Notably, Ocker (2005) and Nemiro's (2007) findings could well be found in studies of creativity in traditional contexts.

Though a small number of studies (e.g. Nemiro, 2007, Ocker, 2005) have looked into creativity in VTs, we identified only two studies explicitly addressing creativity in VDTs—namely, VTs in the engineering design (henceforth design) context. The first study concerns a controlled experiment in which eight VDTs were assessed in terms of quantity, quality, novelty, and variety of generated ideas (Glier *et al.*, 2011); and the second concerns a case study conducted with six VDTs, which contributes a set of factors influencing creativity in that specific VDT context (Chamakiotis *et al.*, 2013). Though these two studies advance our understanding of creativity in VDTs, they do not examine the relationship between creativity and virtuality. We identify this as a knowledge gap emerging from extant literature and aim to address it in this present study. Presented next is our methodology.

3 Methodology

3.1 Research Approach

Much of the afore-discussed research is based on quantitative, 'snapshot' research paradigms which stem from the natural sciences, seek to test made hypotheses or identify causalities between certain factors and certain situations, and inevitably remove the dynamism encountered in organizational contexts (Markus and Robey, 1988). However, isolating single factors from organizational processes that involve human activity, and developing factor-models may not be germane to the study of VTs (Clear, 2009), or that of creativity in VTs, where organizational processes are shaped through the interaction of actors and events (Newman and Robey, 1992). In contrast, in this study, we follow an open, interpretive approach to allow any findings to emerge from it, in our quest to understand how the unique characteristics of virtuality influence creativity in the VDT context. Our approach is mostly qualitative, aiming to pursue a better understanding of the phenomenon under investigation, yet, it has quantitative elements, i.e. ideas count.

3.2 Research Site

We focused on a single VT and investigated it as closely as possible. This approach offers considerable advantages, such as that of being able to understand a single research context. Therefore, we chose ESTIA24 as a research site and pursued a case study with a single VDT, partially distributed between the UK and France in October 2010. ESTIA24 is organized by a French engineering university every year and invites students from across the world to partake in a 24h-long project, to be held either virtually from different locations, or in the French site, in order to design a prototype selected from within a large number of design briefs. The teams enjoy the freedom of working around their design task in their own ways. The VDT we investigated involved two subgroups of engineering students from the UK and France studying in the respective countries. Their characteristics are outlined in Table 1 below. The design process was observed throughout from the UK site. Therefore, we acknowledged an important limitation of our study prior to its commencement; that most of the French subgroup's activity would be missed.

3.3 Data Collection and Analysis

In this section, we discuss the methods we used to collect, and subsequently to analyse, our data. The collected data can be grouped into four categories: video recordings, written outputs, interview data, and supporting material (Table 1).

Category	Type	Coll. Method	No.	Length
Video Recordings	IP-based VC	Video camera	8 sessions	175 minutes
	Skype VC	Video camera	5 sessions	125 minutes
	Skype IM	Forwarded	5 dialogues	-
	UK interactions	Video camera	-	485 minutes
	Computer-Aided Design (CAD) Work	Panopto	Insignificant	Insignificant
	Internet research	Panopto	9 sessions	660 minutes
Written Outputs	Emails	Forwarded	3 emails	Insignificant
	Photos	Manual Collection	74 files	-
	Physical drawings	Manual Collection	6 drawings	-
	Notebook notes	Manual Collection	5 items	5 pages
	Flipchart notes	Manual Collection	14 items	-
	Post-it notes	Manual Collection	117 items	-
Interviews Data	Interviews	-	5	~ 100 minutes
	Informal discussions	-	Unrecorded	Unrecorded
Supporting Material	Observations	Logbook	-	8 pages
	Design briefs document	Manual Collection	1 brief	1 page

Table 1. Detailed Data Collection Table

The different datasets used were not used for triangulation purposes, as confirmatory device, which is common in quantitative research, but rather for completeness purposes, sketching a richer picture of our case study (Tobin and Begley, 2004). Video recordings captured the team's interactions in speaking and were generated using a departmental high quality video camera. They include most brainstorming and 'get-together' sessions of the UK participants and all the interactions between the two subgroups, attained via VC'ing. They therefore combined audio and visual material. Skype VCs were recorded both with the video camera and by the participants themselves using Panopto—a software program a priori installed on their laptops—that captures screen and audio activity.

Written outputs concerned all written communications between the two subgroups (i.e. emails, Skype IM); as well as some of the design outputs. Xobni had been installed on the participants' laptops to count, measure the frequency of, and record their email activity, but the participants found its use confusing and instead forwarded all their written communication to us once ESTIA24 was over. The volume of the communication-related written data was substantially lower than the other types of data, and the number and content of emails exchanges, in particular, were insignificant. All physical drawings (made on flipchart papers) and post-it notes the UK participants produced while brainstorming were collected post-ESTIA24. Photographic evidence of the above was also collected.

Interview data involved both informal discussions had with the participants prior to ESTIA24 and reflection interviews at the end. Initially, background information was collected, whereas the reflection interviews, which lasted around 20 minutes each and were semi-structured in nature, addressed: the participants' initial expectations; their experience and the challenges they faced; the virtual aspect of ESTIA24 and whether they could relate this to previous experiences; dynamics within and beyond their subgroup; their views on the task and its creativity; an example of high and/or low creativity; and an overall reflection.

We began our analysis by watching all the recordings and counting the ideas the participants came up with. Typical phrases when coming up with a new idea were: "How about… What if…". Watching the recordings and looking into our logbook observations taken throughout the 24h enabled us to identify the different stages of the 24h-long design process, extract the ideas generated during the process, and place them under the phases during which they were generated. In identifying the different phases, we were also able to see the environment in which each idea occurred (e.g. team, individual) and the medium through which it occurred (e.g. VC, Skype). We also identified management issues (e.g. how they would communicate, or when they would communicate next). This breakdown of the design process was initially performed on large flipchart papers whereon we placed each idea using post-it notes on a 24h timeline, using post-it notes of different colours, and was later transferred and inserted into an Excel spreadsheet where we also included the ideas we extracted from the team's physical drawing and post-it notes. Once all design-related ideas were placed rightly where they belonged, we attempted to trace all ideas and understand which of them were combined, died, or survived to the end. Insofar as management issues are concerned, these were looked at separately and were put together into different categories. Lastly, we transcribed the interviews manually and inserted them into QSR NVivo 9, where they were analysed thematically using open and axial coding. Our axial coding was informed by relevant literature. Next, we analyse and discuss our findings.

4 Analysis and Findings

4.1 Individual- and Team-level Characteristics of the VDT

We begin our analysis by presenting the individual- and team-level characteristics of the participants in our study (Table 2). Insofar as the individual-level characteristics are concerned, and barring the French subgroup which we did not look into closely, the UK participants were highly homogenous with one variation in terms of nationality and first language, and another in terms of whether they had pursued an industrial placement or taken a specialism in their degrees. It is also necessary to discuss the team-level characteristics.

Name	**Craig**	**Dylan**	**Henry**	**Ryan**	**Sean**
Nationality	British	British	Chinese	British	British
Language	English	English	Cantonese	English	English
Gender	M*	M	M	M	M
Age	22	23	24	23	22
Subject	Mechanical Engineering	Mechanical Engineering	Mechanical Engineering	Mechanical Engineering	Mechanical Engineering
Specialism	Design	Design	-	-	Design
Placement	N*	N	Y*	Y	N
Year	4th	4th	5th	5th	4th

Table 2. Presentation of the UK Participants
**M=male, Y=yes, N=no*

The team's task was to design an 'eco-citizen object for the office;' a design brief they selected from a document listing 34 possible product/service ideas. The brief was broad and lacked an illustration,

allowing for freedom and creativity. The VT falls into the category of PDT, as it comprised two physically collocated subgroups (the UK and the French one) and had no isolated members. To overcome the geographical dispersion boundary the team used a number of ICTs to communicate and collaborate. We provided them with limited use of an IP-based VC system whose use they distributed themselves over the 24h. They also used instant messaging (IM) (i.e. Skype), some synchronous Skype communication (as the time we allowed for VC did not suffice), emails (minimally), YouTube (at the latter stages to pass on videos on one another), and undeniably F2F communication within each subgroup. However, F2F communication was not possible between the two subgroups, as the UK one were based in the UK and the French one in France.

4.2 Creativity and the Design Process in the ESTIA24 VDT

Figure 1. An Unorganized Representation of Generated Ideas in the VDT

Our analysis showed that the VT produced a large number of ideas which they gradually processed, reshaped, and enhanced—an on-going process that ultimately led to the production of finished ideas. Once the design brief was selected (during the first hour of the 24h), the team knew their task was to design an 'eco-citizen object for the office'. In Figure 1 we provide in a wordcloud an unorganized representation of all the design-related ideas that emerged throughout the 24h. As we show graphically in Figure 2, most ideas emerged early on, during the conceptual stages of the design process, and were either finished ideas (products) or, most commonly, unfinished ideas (about design elements/features). We observed that, despite the fluctuant character of creativity, during the latter stages of the process the amount of generated ideas was considerably lessened, as issues of physical fatigue, and reduced motivation, among others, affected the team members. Notably, of the 197 ideas, only 37 were generated from 0030 until 1300 (Figure 2).

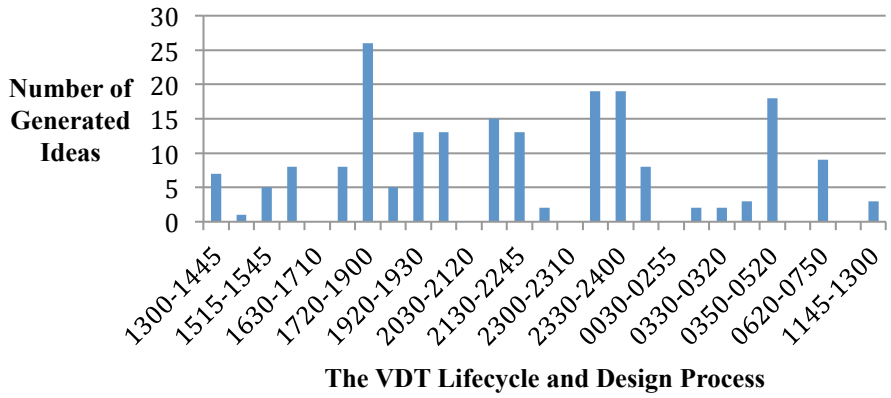

Figure 2. Creativity during the VDT Lifecycle

Next, we present our analysis of the issues that were found to influence creativity in our effort to understand how creativity is influenced by the unique characteristics of virtuality.

4.3 Influences on Creativity in the ESTIA24 VDT

	Enhancers of Creativity		**Inhibitors to Creativity**	
	Major	**Minor**	**Major**	**Minor**
Boundaries			**Differences in education and culture** generated boundaries that **inhibited shared understanding of (a) VDT collaboration and (b) concepts and their roles, significance and rationale** Boundaries in culture **augmented the perceived distance between the two subgroups**	Boundaries owed to education influenced the **difference approaches** taken toward VDT work
Language		Lack of language fluency leading to **different expressions of creativity**: acting out a concept	Lack of language fluency making the participants **lose track**	Lack of language fluency leading to **reduced elegance of describing ideas**
Geographical Separation	Geographical separation between University A and ESTIA24: **lack of direct pressure by organizers** leading to more creativity Geographical separation between University A and ESTIA24: **absence from ESTIA24 social events and temptations helped the subgroup remain more focused**		Geographical separation between the two subgroups: **idea generation process being partially missed** Geographical separation between the two subgroups: **work duplication / working on unrelated tasks**	Geographical separation between University A and ESTIA24: led to the team **selecting a design task they were not happy with**.
Subgrouping			**Multidimensional Subgrouping**: Locational, Cultural, Linguistic, Educational	

CMC			CMC causing an **artificial environment** characterized by the **need to take turns**, **fixed participant positions** and **lack of spontaneity** **Lack of pertinent ICTs for design** (e.g. shared blackboard); inhibiting use of *pen and paper* techniques	Synchronous ICTs were either **costly** (i.e. VC) or of **poor quality** (i.e. Skype) Asynchronous ICTs were either **abstractive** or **time consuming** (e.g. uploading videos on YouTube) **Lack of CMC management and coordination mechanisms** CMC **reducing levels of visibility and clarity** between subgroups

Table 3. Synopsis of Influences on Creativity in the ESTIA24 VDT

Table 3 synopsizes the findings on the influences on creativity in the VDT investigated, and provides short illustrations of the way in which creativity was influenced. These findings emerged from our analysis and relate to the following unique characteristics of virtuality, which are also found in the literature: boundaries, language, geographical separation, subgrouping, CMC, and VDT lifecycle. Further, different roles were identified; for example, certain characteristics acted as enhancers of creativity, whereas others as inhibitors, while some played a major and others a minor role.

Boundaries took many forms—for example, reducing visibility between the two subgroups: "*Maybe we should let them talk first this time […] Now that we see what we each have … we will develop our ideas further and we will ring you back in two and a half hours and we should then be in a position to take things forward*" (video extract) and clarity "*Do we want to make one object between us (the two subgroups) or two objects that work together*" (video extract). Our findings also highlighted that the cross-boundary dimension of the VDT influenced creativity. Most commonly, these boundaries were found to be education-, concept- and language-related. For example, the different subgroups followed different ways to deal with the task, due to their different educational background: "*I think **your job as a designer, as an engineer, is to investigate the original problem**, and decide if that is actually the problem, or if something else is the problem. A lot of the times what you're told is the problem is not the problem.*" (interview extract). Overall, boundaries were found to inhibit the VDT's creativity. These findings also highlight the dimensional character of the two subgroups. The VDT under investigation was comprised of two subgroups which were highly homogeneous within them, and highly heterogeneous between them. It was found that this multidimensional type of subgrouping—emphasizing locational, educational, cultural, and other differences—exacerbated the influence of the afore-discussed boundaries.

Language differences were found to have a twofold effect. On the one hand, lack of language proficiency led to alternative ways of expressing ideas; by, for instance, acting out the functions of a concept on VC. On the other hand, however, language differences slowed down the creative process. As a participant put it, "*language barriers **you have to speak much slower** and use less, simple language to describe it, so normally for me at least, **I go quickly through ideas, but then I had to slow down a lot***" (interview extract).

Geographical separation between the two subgroups also influenced creativity in the VDT. On the one hand, geographical separation between one subgroup and the ESTIA24 main site meant that the former were able to remain concentrated on the task and retain high degrees of creativity with no distractions, while it also gave them freedom to be more creative as they were not receiving pressure

from the ESTIA24 organizers. It also meant, however, that an unsuitable design task was selected due to one subgroup not being physically present when the tasks were being introduced to the participating teams. Further to these enhancing and inhibiting roles of geographical separation between the UK subgroup and the ESTIA24 site, geographical separation between the two subgroups that comprised the VDT influenced creativity negatively; it led to work duplication which was counterproductive, and, importantly, it resulted in much of the creativity process being missed: "*... you come up with a solution, but* ***all the process you've gone through to arrive at that solution, you wouldn't actually share it****, and lots of the time that information is more viable, or just as viable as your final solution, because* ***they might have excluded something which we would have included***." (interview extract).

CMC is what enabled the two subgroups to come together and form a VDT, yet it is what inhibited their creativity as well. Our findings suggest that CMC created an artificial work environment: "*...* ***we had to take turns to talk*** *whereas* ***in reality when you have a conversation, people jump in all the time, you sketch, you go around*** *[…] turns became more like, about going through an agenda, going through, stating, what we had done, but then not really having a discussion […]* ***it was always from this fixed position*** *[…] you could [not] see what they were looking at […] they had one static camera and then they were zooming into the board, and we would miss all their facial expressions […] a lot of the time you have like* ***a moment that comes to you very quickly and you either need to share it quickly or you can forget*** *what you were thinking.*" (interview extracts). What is more, the ICTs used were not pertinent to the design task. For example, the participants argued that emails would be very distracting. As this quote highlights, though the ICTs the VDT used may have had disadvantages, they did nevertheless help the participants be creative collaboratively: "*We were showing them ideas like, one of my ideas, the time capsule, you flip it round, the sun goes up, and say if you don't recycle or put the rubbish somewhere then the earth is sinking,* ***we didn't realize it would have been better to have one side half of it and the other side the other half. They had the ideas, you know when people look at your design and have more ideas, at the end they got it but it took like 10 minutes***." (interview extract).

5 Discussion and Contributions

Our study (a) presumed that creativity in VTs has not been researched adequately, though the unique characteristics of virtuality may exert an influence on creativity and render therefore practices developed in the traditional environment unsuitable; and (b) used design as a pertinent empirical context. ESTIA24 was a pertinent research site because it allowed us to investigate the VDT from initiation to termination and acquire a relatively complete image of the VDT, while our highly diverse dataset provided a rich picture of the case study. Though the literature offers some useful accounts of creativity in VTs (e.g. Chang, 2011, Ocker, 2005) and in VDTs (Chamakiotis *et al.*, 2013, Glier *et al.*, 2011), the relationship between creativity and virtuality had not been previously unpacked. Rather, these studies have either provided factors that may be relevant in any context (virtual or F2F) or have focused on other issues (e.g. quality of generated ideas). With our study, we extend this literature by (a) positioning creativity within the VDT lifecycle; and by (b) providing insights on how the unique characteristics of virtuality that emerged from our analysis influences creativity in a VDT context.

Our findings inform literature on the VT lifecycle (Hertel *et al.*, 2005) by positioning creativity within it. Specifically, we found that creativity in the VDT is influenced by the design process and is high during the conceptual design phase. Further, though it diminishes in the latter stages, still creative moments can occur. Our findings also extend literature on boundaries in VTs (Panteli, 2004a) by highlighting that these can take many forms (e.g. educational, conceptual), reduce visibility within a VDT, and overall inhibit creativity. Subgrouping constitutes a unique organizational configuration within VTs (Panteli and Davison, 2005), and, further to subgroup dominance influencing creativity in VDTs (Chamakiotis *et al.*, 2013), our findings show that if subgroups are highly heterogeneous, i.e. they vary in more than one aspects, as it has been the case in this case study, they act as major inhibitors to creativity. Similarly to previous research (Chamakiotis *et al.*, 2013), difficulties in language use led to alternative way of expressing ideas. Geographical separation, rather than

dispersion, was found to be the case in this VDT. Geographical separation was posited (a) between the two subgroups and (b) between the UK subgroup and ESTIA24. It was found that the former had a twofold effect, both enhancing and inhibiting creativity, while the latter mainly had a detrimental influence on VDT creativity, resulting in participants missing large part of the creative process. CMC inhibited creativity too, by, for instance, slowing down the creative process and by creating an artificial environment in which the participants found it challenging to be creative collaboratively.

Our study is significant as it is the first to start sketching a picture of how creativity is influenced by the unique characteristics of virtuality in VDTs. Importantly, we show with our study where creativity occurs during the VDT lifecycle. Moreover, though others scholars (e.g. Nemiro, 2007, Ocker, 2005) have looked into creativity in VTs, these studies do not show how virtuality influences creativity.

6 Limitations and Implications

We have identified the following limitations: (a) geographical separation was an important limitation, as it did not allow us to record the French subgroup's activity; (b) observations and interview data were subjected to the researchers' interpretations; (c) the participants were students and these findings may be insignificant in industry; and (d) statistical generalizability is constrained due to small sample size. These limitations give rise to future research. For example, taking the case of industrial VDTs may be more valuable to practitioners, while inclusion of other types of VDTs, with varying degrees of heterogeneity, ICTs used, and geo-temporal dispersion, will further increase our understanding of creativity in VDTs. Our study also has implications for practitioners. For example, bringing individuals together by solely providing them with the ICTs to use does not suffice for creativity. The virtual character may generate boundaries that inhibit visibility between VDT participants, resulting in much of the creative process being missed. Pertinent ICTs must be in place that will allow them to share their designs more easily (e.g. shared boards).

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