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THE CREATIVITY OF VIRTUAL DESIGN TEAMS: AN EXPLORATORY CASE STUDY

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Abstract

Creativity is a topic of interest across numerous disciplines and areas of study. While in engineering design some stages of the design process have become highly dependent upon technology and Computer-Aided Design (CAD) tools, scholars in the field of management claim that the impetus for virtual teamwork calls for research as to how the new, boundaryless virtual arrangements alter some of the management practices built surrounding the physically-located workplace. In this paper, we reveal a knowledge gap on how creativity is influenced in the virtual design context. In our quest to start bridging this gap, we pursued an exploratory case study with a student-based virtual design team project, known as the European Global Project Realization (EGPR). Thirty-nine interview extracts from most participants in the EGPR provided us with insights into the nature of the project, the participants' perceptions of creativity, and their experience of designing in virtual teams. The qualitative data collected from these interviews were triangulated by observation and document review and were analysed thematically, in line with our theoretical model derived from the literature review. In all, our study contributes to the current body of knowledge by identifying some of the factors that influence creativity in virtual design teams (i.e. motivation, experience/training, subgrouping, diversity and knowledge, supervision, industrial partners, project importance, Information and Communication Technologies (ICTs)).

Keywords: global virtual teams, virtual design teams, distributed design, creativity.

1 INTRODUCTION

Creativity is a notion which is difficult to define, an ambiguous term some argue, yet there appears to be consensus that it has to do with the production of original ideas that are both new and useful. In design, creativity is imperative when practical problems emerge (Von Stamm, 2003), while in management, the prevalence of the virtual, computer-mediated, and globally-dispersed structures, along with the need for the development of a competitive advantage, have rendered creativity a must-have ingredient (Andriopoulos and Dawson, 2009). Therefore, the study of creativity in Virtual Design Teams (VDTs) is one of multidisciplinary value for researchers and for practitioners alike. Despite however the widespread recognition of the importance of creativity in any virtual milieu (Nemiro, 2007), admittedly little is known about this area of study; very few researchers have dealt with this particular area, and creativity in VDTs as such has to date received almost no attention. Consequently, given the newness of this topic, the aim of our study is to explore creativity in the VDT context and to identify (a) some of the factors that influence it, and (b) fertile areas of research in this context. Further, while previous studies on Virtual Teams (VTs) have looked at several issues (trust, leadership, etc.) as a means for improving their overall performance and effectiveness, our study is interested in creativity as such, and therefore, looking at the associations between creativity and performance is beyond its scope. Nor is our aim to attribute the factors that we aim to identify to the virtuality of the teams; rather, we examine whether, and to what extent if so, some of the factors associated with creativity in the traditional literature are relevant in the VDT context. Given the exploratory character of our study, we pursued an exploratory case study with a student-based VDT project, known as the European Global Product Realization (EGPR), and conducted interviews with most participants.

The qualitative interview data were analysed thematically, in line with the three levels of creativity, while our approach allowed for new themes to emerge under each level. We also attempted to triangulate the interview data with observations and document review as a form of strengthening the credibility of our analysis. Our findings show that there exist factors that influence creativity at all levels, and it contributes to the creativity literature and also to the VT literature and the engineering design one, whilst also offering direction for future research. We begin by presenting a cross-disciplinary literature review of creativity which we then narrow down to the virtual design context. We continue by presenting our research method and site. Subsequently, we present our findings thematically, and discuss their contribution and implications for theory and practice.

2 LITERATURE ON CREATIVITY

The following review is focused on creativity; first as discussed in the organizational literature, which allows us to form a broad picture of it, and then in the virtual design context. In narrowing down our scope, we also discuss engineering design and VTs in order to understand the unique characteristics that underlie VTs and VDTs by extension, which might require an alternative approach to supporting and enhancing creativity.

It is well-recognized that there exist a wealth of studies on the topic of creativity. This wealth lies in multiple disciplines, including, among other, the organization, psychology, management, and education discourses. While, notably, there is no fixed definition of creativity, one may argue that it is generally seen as a process (e.g. generation of ideas) or as an attribute, and has been investigated predominantly through the lens of the *individual*, the *team*, and the *organization*; hence, at three intertwined levels. And in association with the *person*, the *product*, the *process*, and the *press* (with the latter referring to the pressures enacted by the organizational environment); hence, with the so-called 4Ps (Richards, 1999). Initially, research into creativity centred on the individual level and found that *cognitive factors*, *personality traits*, *relevant knowledge*, and *motivation* are closely associated with it (e.g. Amabile, 1988; Andriopoulos and Dawson, 2009).

With time, however, scholars have studied team creativity, assuming that the more the people, the more or the better the ideas (e.g. West, 1990); a view that later received substantial criticism. Staw (2009), for example, succinctly shed light on the fact that bringing people together alone by no means insures a creative outcome; as he argued, it is as though people assume that teaming *must* be effective; a view that he sees as incorrect, owing to centrifugal forces often posited in teams. Additional factors to be taken into consideration are: *heterogeneity*, *diversity*, and *group composition* (Woodman, 1993). The creativity discourse has been taken to another level; the organizational. Factors introduced at this level include: *organizational climate*, *leadership style*, *organizational culture*, *resources and skills*, and *structure and systems of an organization* (Andriopoulos, 2001).

2.1 Creativity in Design

Design research is a relatively new discipline, when compared to that of management for example; and defining design can be difficult. The chosen working definition for design in the present study is: “... *a specification of an object, manifested by an agent, intended to accomplish goals, in a particular environment, using a set of primitive components, satisfying a set of requirements, subject to constraints*” (Ralph and Wand, 2009). Communication affects the effectiveness of the design process, as also do creativity, collaboration/teamwork (Chamakiotis *et al.*, 2010), and technology (e.g. Computer-Aided Design (CAD)). In fact, the supreme complexity of today’s products has taken teamwork to a global level and thereby global design teams have developed. Research into this has been scant and the creativity of such teams has not been explicitly looked at. Rather, Monalisa *et al.* (2008) found that these teams often fail due to *technological*, *organizational*, and *personal* reasons. However, it has been suggested that this global connectivity and by result collaboration may, despite debates in the field, be advantageous. For example, for Osborn’s well-known for idea generation *brainstorming* technique, as it may reduce the commonality of ideas encountered in a physically-collocated working group (Elias *et al.*, 2011); such an assumption may possibly be owed to the higher diversity of individuals encountered in global teams, and increasingly, in VTs, as we will be elucidating in 2.3. Previous research agrees with this view that high levels of diversity among VDT participants may exert high levels of team creativity (McDonoughIII *et al.*, 2001).

A question that nonetheless arises is whether all design activities and stages necessitate creativity, and the answer to this may be found in the two classifications that follow. Design types can be classified as per their novelty: from *original*, when incorporating new solution principles; to *adaptive*, when embodying an established solution to satisfy new criteria; and *variant*, when varying certain system aspects within limits established by previous design structures (Pahl and Beitz, 1984). Design types have also been classified according to their degree of creativity, as *routine designs*, *innovative designs*, and *creative designs* (Gero, 2001). Gero (2001) spoke of the ‘design space’ and made the point that creative designs shift the design space by introducing new variables, whereas innovative designs only require extra knowledge within the progenitor’s space. It follows, therefore, that not all design tasks require the same degree of creativity, but rather that the design brief – which constitutes the designer’s roadmap and results from the need to cover customers’ needs – plays a large part in defining the degree of creativity needed. Considering also that VTs are increasingly used in design, we now turn to a discussion around VTs which will help us understand their unique characteristics that might render it difficult for creativity to flourish.

2.2 Creativity in Virtual Design Teams (VDTs)

VTs are defined as “*groups of geographically and/or organizationally dispersed coworkers that are assembled using a combination of telecommunications and information technologies to accomplish an organizational task*” (Townsend *et al.*, 1998). Research into VTs has underlined their main characteristics, which are *geographical dispersion*, *computer-mediation*, and *shared objectives* among their members; and have addressed some of their benefits and challenges (Bell and Kozlowski, 2002; Duarte and Snyder, 1999; Jarvenpaa and Leidner, 1999; Kayworth and Leidner, 2000; Lipnack and Stamps, 1997).

In this study, we group under the term VTs all such teams that share the aforementioned characteristics and which have been referred to as ‘computer-mediated’, ‘dispersed’, ‘global’ and ‘distributed’. Benefits when deploying VTs might include accessing the most skilful human resources worldwide, as well as flexibility for both the employer and the employee, while challenges concern trust development or effective leadership. The aforementioned studies have highlighted that VTs are not without challenges and have asserted that *e-leadership*, *trust*, *subgrouping*, *conflict*, and *diversity* explain the occasionally paradoxical image of VTs, posited when VT members find it difficult to collaborate and achieve their goals. However, as we also mention in the introduction, while the aim of most of previous VT work has been to investigate these issues in order to improve VT performance, our scope here is creativity as such and not its association(s) with performance. Further, the literature has uncovered different types of VTs, like, for example, *global or local*, *inter- or intra-organizational*, and *temporary or permanent* (Panteli, 2004), and has identified other such contributing issues as the role of media used and their degree of synchronicity (Palmer and Speier, 1998).

Common denominator of all these studies is that they treat VTs as a new, different working arrangement, completely different from traditional teams. Increasingly, however, scholars have begun to describe VTs in relationship with their varying degrees of *virtuality* – or *virtualness*. Griffith *et al.* (2003) found that some teams are *pure virtual* and other *hybrid*, in addition to Dixon and Panteli (2010) who spoke of *virtuality in teams* rather than VTs. These new conceptualizations of virtuality are closer to our understanding and also to industrial paradigms across different industries (e.g. high-tech, aerospace engineering) and more relevant in design practice. Nevertheless, however virtual teams might be, their creativity remains a relatively unexplored area. The following section summarizes the different literatures and identifies some of the knowledge gaps.

In general, creativity in VTs has not been studied much, particularly in design; with some exceptions though, such as that of Ocker (2005) who identified a number of enablers of (e.g. *stimulating colleagues*, *collaborative climate*) and inhibitors to (e.g. *dominance*, *technical problems*) VT creativity. Similarly, a study conducted using a leading global organization in the sales industry revealed that *technology-*, *task-*, *individual-* and *organization-related* factors exert an influence on VT creativity (Chamakiotis and Panteli, 2009), while a more longitudinal study, carried out by Nemiro (2007) with designers, consultants, and other professionals, labelled five building blocks that companies need to have in place for creativity to flourish in their VTs: *design*, *climate*, *resources*, *norms and protocols*, and *continual assessment and learning*. Connection, in particular, which falls into the second block, has been seen as *task* and *interpersonal* (Nemiro, 2001), while the creative process which is relevant to the first block has been broken down to seven phases: *preparation*, *incubation*, *generation*, *emanation*, *selection*, *finalization*, and *evaluation* (Letaief *et al.*, 2006).



Figure 1. Factors influencing VDT Creativity (after Chamakiotis *et al.*, 2010).

Our review reveals that despite the importance of and wealth of studies on creativity in general, creativity in the virtual design context has not been investigated. Though, for instance, some enablers of and inhibitors to creativity in VTs in general have been identified in the literature (e.g. Ocker 2005), this research may not be relevant in the design context; hence, our research will seek to investigate whether these findings are transferable in the context of VDTs, whereby the unique characteristics of virtuality might render these previous findings irrelevant. In design, on the other hand, some factors that are related to the effectiveness of global design teams have been unpacked, but it is to date unknown whether these same factors influence creativity. Therefore, in this study we will consider the three creativity levels (i.e. individual, team, organizational) to explore the area in some depth and perhaps uncover factors that influence creativity in VDTs in particular. These constitute our aims from this point on, though other gaps continue to emerge. To amplify our argument and selection of the three levels as the lever that will drive the rest of our study, we espouse Chamakiotis *et al.*'s (2010) model which shows the importance of the individual, team, and organizational factors that influence VDT creativity (figure 1). Specifically, the model shows that creativity is dependent upon the interaction between the individual and team characteristics attained through the use of Information and Communication Technologies (ICTs), which along with the design task and the social and organizational influences act as determinants of VDT creativity and output. Having now positioned the thesis of our paper, we move on to discuss a suitable methodological approach that can serve in answering our questions.

3 METHODOLOGY

3.1 Research Stance

We selected this methodological approach because of the nature of our research aims. As therefore, we immersed ourselves into an exploratory case study to collect our data. In view of the multidisciplinary nature of our study, we have to be consistent with the use of terms that might have different meanings in different disciplines. Herewithin, we adopt the term 'case study' as a research strategy, consistent with management research, and not to refer to an industrial example, which is commonly the case in engineering practice. Case studies are suitable when the phenomena under investigation are of complex nature and embrace a social real-life context (Yin, 2003) or when assessing phenomena in a new light. Attempting therefore to explore the phenomenon of creativity under the light of the virtual design context may stand as a justification for the selection of this research method. Crucial for the exploratory case study was the selection of our research site, which we will be discussing next.

3.2 Research Site

The selected research site for this study is the European Global Product Realization (EGPR) project. The EGPR prides itself for bringing together students from different European Universities in an effort to prepare them for real life projects. It is described as "*a videoconferencing-based engineering course*" (Zavbi *et al.*, 2007), while one or two industrial partners are also present each year to supply the working materials, give feedback, and capitalize on the students' creative ideas. Its organizers stress that the EGPR is all about teamwork, and, in their own words, "*... when we initiated EGPR, the idea was that students graduated from university with no real work experience; with EGPR, we have overcome the limitation that students don't have work experience when they graduate [...] it shows that different nations can work together and produce very high quality work [...] friendships and long-term collaborations develop ...*" (observation extracts).

Due to its innovative set-up, the EGPR has attracted some academic interest, but this has mainly yielded results that (a) gauged the pedagogical impact (Zavbi *et al.*, 2007), and (b) investigated design competence development (Kovacevic, 2008). These studies recognize the significance of creativity in the EGPR but they have not looked at it. Given the literature review earlier, research into creativity can be conducted via interviews, not only questionnaires, which can help the researcher interpret, not only measure, the 'why' behind actors' behaviours in organizational settings. Further, the

aforementioned studies' aim was principally to improve the quality of the EGPR and not to centre on the phenomena under investigation as such.

The students collaborate virtually (except during the last phase) for a period of five months (February-June) during the spring semester, broken down to four phases (table 1), aiming to design, assemble, and present a prototype. All participants are given access to a number of communication media and are required to attend a number of lectures held virtually, regarding designing virtually. During the academic year 2009/2010 four European Universities, each from a different country, partook. Though there are variations with regard to the participating universities each year, one university assumes a leadership position, hosts the fourth phase of the project, and defines who the industrial partner(s) will be. One or two industrial partner(s) each year decide on the product, give students feedback, and provide them with the materials. The first three phases are held exclusively virtually (with the students based in different locations and with them not having met one another face-to-face (F2F)), whilst in the fourth phase students get together in a traditional, F2F environment to assemble their prototypes and give the final presentation on them. The entire process is monitored by the industrial partners at the project reviews, upon completion of each of the three virtual phases. By the end of each phase, the students have to complete a report for their assessment and have the chance to receive industrial feedback and proceed to the next phase.

	Phase	Context	Objective
Phase 1	Market Research	virtual	Market Research and Design Problem Definition
Phase 2	Conceptual Design	virtual	Functional Requirements and Morphological Charts Development
Phase 3	Design Finalization	virtual	Detailed CAD Models of Selected Products
Phase 4	Final Workshop	F2F	Prototype Assembling and Presentation

Table 1. The EGPR Phases.

In all, the EGPR proves suitable in our quest to undertake this study in the following manners:

- It deploys hybrid teams with varying degrees of virtuality and physical presence and different boundaries, and is therefore quite close to industrial reality.
- The involvement of the industrial partners differentiates the project from completely student-based studies, as the EGPR students have real deadlines, materials, etc., while the European dispersion (as opposed to dispersion within one university) brings the project closer to industrial paradigms.
- These projects are considered successful and are likely to lead to discovery of a good balance of enablers of and inhibitors to creativity.

3.3 The Sample

A large number of students from the four European Universities involved in the EGPR participated, resulting in thirty-nine interview extracts (table 2). Six teams were formed, of which five comprised seven students and the remaining one comprised eight students. Moreover, physically-located subgroups existed in all teams; specifically, each team would have 3 or 4 participants from Slovenia, 2 participants from Hungary, 1 or 2 participants from Croatia, and 0 or 1 participant from the UK. In addition to the students, a supervisor, called '*the coach*' was assigned to each team. Either a faculty member or an EGPR alumnus/a, the coach was accountable for the teams' presence in the videoconferencing (VC) meetings, directing their team and giving them advice, answering questions, and ensuring their team was on track. Half of the teams were tasked with designing a toilet flushing system and the other half a kitchen blender (table 2). 'x' stands for the number of times each

individual was interviewed, which resulted in thirty-nine interview extracts. It is also important to highlight the individual- and team-level characteristics of our sample.

	Product	Team Participants	Phases 1-3 Interviewees	Phase 4 Interviewees
Team 1	kitchen-blender	8	1x3	4
Team 2	kitchen-blender	9	1x2	5
Team 3	kitchen-blender	8	1x2 & 1x3	3
Team 4	toilet flushing-system	8	1x1	3
Team 5	toilet flushing-system	8	1x2	3
Team 6	toilet flushing-system	8	2x2	4

Table 2. Presentation of the EGPR Teams.

3.3.1 Individual-Level Characteristics

The EGPR participants (students and coaches) varied in many aspects: nationality, gender, mother tongue, level of English, education, age and others. The students were all nationals of the country in which they studied, barring the four students from the UK, who were not UK nationals (one European, three non-Europeans). Hence, the mother tongues spoken by the students were (in alphabetical order): Croatian, Hindi, Hungarian, Persian, Slovenian, and Spanish. English – the EGPR working language – was therefore a second language for all students, and this, as per the results, importantly influenced team collaboration. A high proportion of the participants were male, and by extension, each team would only have one or two female participants. With respect to the students' education, the EGPR drew from mechanical engineers (Croatia, Slovenia, UK), industrial designers (Slovenia) and industrial engineers (Hungary). The sample was relatively homogeneous in terms of their age. Of the six coaches, half were faculty members and the other half EGPR alumni from a previous year. Again, English was a second language for all coaches too, while the most significant differentiator among them was the country of origin (respective of each participating country, except one non-European coach), and the level of experience.

3.3.2 Team-Level Characteristics

It is imperative to clarify the communication media the teams employed to collaborate. The teams conducted two VC meetings per academic week (excluding holidays). VC constituted the only synchronous method of communication provided by the EGPR organization. Furthermore, students were given access to an *FTP-server* and to *Huddle*, an online tool for managing people, projects, and business information securely. These tools allowed them to save files at any time from different locations and proved useful for exchanging drawings and being able to rotate the workload. The students also used *Skype* in subgroups within their teams.

Subgrouping was an important facet of the project too. Although maximum dispersion was aimed by the EGPR organization, which means ideally each VT member would be based elsewhere, physically-located members existed in all teams, particularly in Slovenia. This arguably lessened virtuality in some teams, and influenced the dynamics within them, as the physically-located subgroups of each team had the opportunity to collaborate in a traditional, F2F environment too during the project.

3.4 Data Collection and Analysis

Semi-structured interviews, individually (1 interviewee) and in focus-groups (up to 7 interviewees), constituted our primary data collection method (table 2). Churchill (1999) argued that in exploratory

research, in-depth, semi-structured interviews are fruitful; thus, our data collection method is consistent with our research purpose. In addition to interviewing, several documents were reviewed (e.g. course syllabus) and processes observed (figure 2), which gave us deeper insight into the project.

Though large part of the data were collected upon the fourth phase in a F2F environment, most prior interviews were held in person, with a few exceptions over *Skype*, and lasted from 20 to 60 minutes each. Consent for audio-recording was given, while it was agreed that the data would be used for research purposes only and sensitive information would not be disclosed. During the interviews, the participants gave their views and also examples regarding the project itself, their motivation, their performance, the virtual aspect, and of course their reflections on creativity in the design process. Observation, on the other hand, occurred principally during the fourth phase and also during some hours of VC interactions from the UK and Croatia sites during the first and second phase respectively.

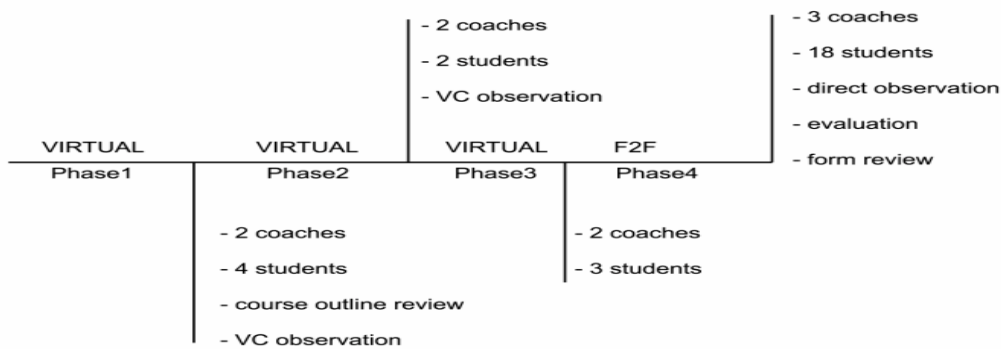


Figure 2. Data Collection Steps.

Thematic analysis and grounded theory were used for data analysis. Thematic analysis has been predominantly used in psychology and similar disciplines and is one that draws from coding schemes emanated from grounded theory. The latter was initially developed by Glaser and Strauss (1967) to develop theory purely from data without any theoretical preconceptions, thus qualifying for topics with limited or no theory, but thematic analysis differs in that it uses codes to develop theory consistent with the literature (Boyatzis, 1998). In our study, we took the three levels of creativity (individual, team, organizational) as the three themes identified in the literature, and we allowed for the generation of subthemes under each to emerge, following a grounded-theory approach. Thus, the factors/themes discussed under each level emerged purely from our findings and were not a priori hypothesized. They were a result of recurrent notions that cropped up through the narratives. The interviews were transcribed manually, and approval from the organizers to refer to the EGPR by its name in this study was given.

4 FINDINGS – ANALYSIS

The study with the EGPR uncovered a number of factors that influence creativity in the VDTs and that correspond to each of the aforementioned three levels. We found that under each level are forces that have either an enabling or an inhibiting role to play, or both. These are discussed thematically below.

4.1 Individual Level

Thompson (2003) noted that it is usually in the 5% of a given sample of people where utter creative ideas are encountered. Accordingly, the EGPR coaches argued almost unanimously that there would be one or two very creative students in each team. As stated earlier though, we are not after numbers in this study. Instead, the individual level herein presented encapsulates factors associated with the individual that make the creative person within this VDT context. The participants in the study, predominantly the coaches, stressed that the particularly creative individuals have played a momentous role for the creativity of their VDTs. In particular, the following factors seemed to loom at this level: *motivation*, and *experience/training*. We discuss these separately:

Motivation: Certain students would be creative irrespective of other associated parameters: “*some students would be creative either way [...] x was a very creative designer [...] the outcome of his attempt was very creative as we all expected [...] there is definitely a personality matter*”. We gathered that there were different levels of motivation among the EGPR participants and this had a significant impact on creativity exhibited by each. As some coaches and students argued, “*... girls are usually industrial designers and are more motivated and more creative [...] because of their motivation and the importance of the EGPR in their career*” (coaches). Motivation in our findings featured insofar that it acted as a redeeming element against language/communication issues, which by some were seen as a problem-causing issue.

Experience/Training: Creativity at the individual level consisted significantly in the level of experience/training of each participant. For instance, “[...] *industrial designers are better-trained for brainstorming and generating ideas*” (coach). As some students claimed, industrial engineers from Hungary were proficient in preparing presentations and therefore despite effortful attempts for good looking presentations on all sides, the ones done by industrial engineers proved always superior in terms of creativity. It seemed therefore that experience is an ingredient for creativity which has been consistently developed throughout the curricula industrial engineers have gone through at their schools. We also gathered that experience outmatched some of the problems (e.g. communication), and that while the most experienced ones were not those with the strongest English, they were those who put their points across more effectively, assumed leadership positions, and exhibited creative behaviours.

4.2 Team Level

Our findings suggest that the teams have exhibited creativity and that interactions within each VDT has borne ideas: “*someone comes one day and says: I have this idea about the blender; a blender that had a manual chopping on the handle and a normal shaft on top, but this was an idea that was initiated by one person and perfected by another in the team*” (student). The factors that influenced creativity at this level were as follows:

Subgrouping: We found three distinct types of subgrouping within each VDT. While locational subgrouping was the most apparent, subgrouping was also relevant to the discipline (e.g. mechanical engineers together), and also task-oriented (certain subgroups were assigned certain subtasks). One of the coaches said that in the VDT he spearheaded, a 2-2-1-1-1 VDT, the centre of creativity was in the subgroups (2-2). Yet, despite the power issues encountered between different subgroups, it was pinpointed that it is a question of direction: “*... [you can] use subgroups in a positive way and you can have them bring something creative and new, instead of competing trying to persuade the others of their opinion*” (coach).

Diversity and Knowledge: We mentioned earlier that diversity was aimed from the EGPR organization, and that higher diversity may result in lower commonality of ideas (Elias *et al.*, 2011). The results suggest that diversity within the VDTs was paramount in terms of knowledge transfer and success, and consequently, in terms of creativity: “*... we started with marketing and I had no idea. The Hungarian girls taught us a lot about it [...] the proposition of the Hungarian girls was closer to what the company wanted [...] initially, I thought my design was the best, then I saw theirs and I realized theirs was a lot better, they are really good designers, a lot more creative [...] we checked what other competing companies did to fulfil different functions, and using this checklist to enhance our creativity was not something that I, as a mechanical engineer, had used before [...] it was something different in my learning [...] I started to use other methods I was not familiar with*” (student).

Supervision: The well-defined supervision from the coaches influenced positively creativity at this level. The coaches’ role was to ensure each team is on track and has someone to seek guidance from; the coaches monitored the email communication and stepped in when problems arose. Specifically, “*We had to push them a bit to show them they could use other stuff as well instead of buttons. So I gave them some ideas to get going. Also we debated a bit so that they started thinking, to get the kick off. Or say, listen, this is not innovative enough, think of something different!*” (coach).

4.3 Organizational Level

The following issues came up at this level:

Industrial Partners: The involvement of the industrial partners is a problematic issue. While this enabled the VDT to feel closer to industry, some companies were afraid that the students would go “... *too deep into their production secrets*” (coach) and were therefore not very cooperative, which at times has lessened the degree of creativity that was requested.

Project Importance: The different grading weight among the different participating universities had a negative impact on the VDT effectiveness and its creativity: “*The project is more important for industrial designers [...] we treat it as just any other project*” (coach); “*not everyone has the same commitment [...] at the moment, although there are expectations from mech eng, I currently have exams*” (student).

ICTs: The ICTs used throughout the project played a twofold role. On the one hand, “*the virtual is for sure a limitation*” (coach). The role of the VC meetings, in particular, was quite ambiguous: “*...when you are in a meeting you know you are there and you pay extra attention, but in the VC you are not as concentrated, which has decreased our productivity and our instant creativity [...] VC is not ideal for drawing sketches [...] if we had better media to pass our sketches, we wouldn't need to go through modelling for 3 different concepts [...] uploading a sketch makes you lose track [...] design should be easily communicated*” (student). On the other hand, however, the VC was seen as a good tool to solve problems instantly: “*... we were fully concentrated on that. We knew the time constraints and we tried to solve all the problems within the time we had. In other situations, I would rather postpone it rather than solve it straight away*” (student). In addition, participants were free to choose among their own ways of communicating virtually; this was most often communication via Skype and was seen as an enabler for creativity. “*... [this] was good because I could have a good idea at random times and then I could send it to others at a different time through Skype. Flexibility combined with schedule and technology are good for creativity*” (student).

5 DISCUSSION AND CONCLUSIONS

Our study satisfied its exploratory aim to identify a number of factors that influence creativity in VDTs. We found that there exist factors at all three levels and these may enable or inhibit creativity, but their role has not been thoroughly discussed at this stage of our study.

Our findings suggest that personal motivation and experience/training play a vital role in enabling VDT creativity. At the team level, supervision is exercised such that it has positively influence creativity, while subgrouping has also influenced decision making within the teams and also their degree of creativity. Organizationally, several dualities (factors that are both enabling and inhibiting for creativity) have been pinpointed, including the role of ICTs and sponsors, whereas the different level of the EGPR importance across the different universities has constituted a major inhibitor.

We initiated this study on the premise that the unique characteristics of VTs may not allow for creativity to occur in the same way as in the traditional collocated environment. We also assumed that factors that influence creativity in VTs in general (e.g. Ocker 2005) may not be relevant in the design context, namely in VDTs. At this stage of analysis of our findings, we can claim that despite the unique characteristics of VTs, some of the factors associated with creativity in the creativity literature, particularly these at the individual level, are still relevant in the VDT context; hence, we may consider *motivation* a core factor that influences creativity. In addition to these factors, we found that teams have to put additional effort to develop a certain level of trust and communication and use subgrouping and power issues for the benefit of the VDTs if aiming for high levels of creativity. Our findings also show that virtuality intensifies the impact that ICTs (e.g. their asynchronous and task-specific functions) can exert on the VDTs' creativity.

Our study carries the following limitations: (a) the narratives are subject to the subjective interpretations of the researchers; (b) the quotes might suffer the interviewees' memory biases; (c) this

was carried out in a highly contrived educational environment which might be not relevant in industry; (d) the EGPR enjoys the luxury of history and well-defined structures – its organizers have built practices and have the tools in place for the project to succeed, and this might not be the case in other projects. Our study also paves the way for future research: (a) discerning and discussing the differences between enablers of and inhibitors to creativity in this context, instead of simply identifying factors, will be of foremost of value; (b) next step would be to couple the qualitative data presented above with quantifiable evidence; (c) it would be interesting to investigate whether similar behaviours occur in a business VDT context and to identify enablers of and inhibitors to creativity in an industrial environment; (c) investigating the relationship between creativity and performance in VDTs is also worthwhile; (d) comparative studies and other research approaches will possibly afford more generalizable results. Though still at the exploratory phase, our study points toward some implications for practice; that VDT managers should ensure to have the systems in place at all different levels (individual, team, organizational) in order to support creativity. More specifically, they should ensure (a) to have in place technologies that serve the purpose(s) of their project(s); (b) that VDT members are familiar with these technologies. If aiming for creative VDT configurations, VDT managers should (c) initiate VDTs with constructive subgrouping and high potential for knowledge transfer; and (d) teams should consist of members with high levels of motivation and increased diversity among them.

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