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Evolution of Communication Skills in Virtual Product Development Process: Experience From EGPR

Nikola Vukašinić, Janez Benedičič and Roman Žavbi

Abstract

More than a decade of continuous international collaboration of several European universities in teaching new product development in virtual environment gives unique opportunity to investigate evolution and development of communication techniques for NPD collaboration in virtual environment. This chapter provides theoretical and practical view on different aspects: technical evolution of ICT tools, development and fostering of communication flow, personal aspects of IT communication, with important emphasis on building of trust within virtual teams. The reader can extract from this chapter guidelines for work in collaborative virtual environment, to run effectively either small projects, meetings and lectures or even more complex projects, distributed among several dislocated teams. The chronological overview of the continuous virtual communication in the last 15 years gives also fair suggestions about future evolution for the next decade.

Keywords: virtual development, new product development, IT communication, virtual team, collaborative virtual environment, project

1. Introduction

New product development (NPD) is a demanding and complex activity as it is, and its level of difficulty is additionally increased by the ever-changing business environment, primarily by functional association of geographically dispersed multicultural human resources [1–5].

A virtual team is an organisational unit potentially capable to perform NPD within actual business environment [6]. A virtual team is a group of geographically dispersed people who interact through interdependent tasks guided by a common purpose with the support of information and communication technology [7, 8]. They showed several advantages compared to centralised local teams, e.g., easier recruitment of best professionals globally, without the need for their physical relocation, better organisational flexibility or the ability to perform relay product development process by distributing and handing over the tasks to teams in different time zones [9–11].

In a virtual development team (but also in collocated teams), good communication is needed for trust building [12], since trust is a prerequisite of the knowledge

exchange, creativity and performance of virtual teams. Faulty or inadequate verbal and non-verbal information exchange hampers team creativity, leads to frustration, misunderstanding and even to conflicts among team members [13]. Therefore, one of the key challenges of virtual teams is effective communication [14].

Sivasubramaniam et al. [15] found that internal communication, external communication, group cohesiveness and goal clarity (as team process variables) are paramount for the success of NPD team. Internal communication refers to frequency and openness of information exchange among team members, while external communication refers to the degree of information exchange with people outside the team and taking advantage of external resources. Group cohesiveness refers to level of interpersonal bonds. Group cohesiveness is more influential in case of intense and interconnected activities, as is the case of NPD. Goal clarity refers to the goal consensus within NPD team. It has been shown that specific and challenging goals are superior to ambiguous and easy goals [6].

In this chapter we will give the overview on evolution of ICT tools and protocols that were used from the very beginning of EGPR course in 2001 when videoconferencing systems were only scarcely used in academic environment, particularly and even less commonly for regular lectures and courses that take place in virtual world until the year 2015, when the era of MOOCs, open access video lectures and ubiquity of information dominate the academic world.

EGPR teams are hybrid teams, since their sub-teams are sometimes co-located and have even common history from other projects during study period. Nevertheless, all the EGPR teams are taken into consideration as they were completely virtual.

2. Theoretical underpinnings

Verbal communication delivers only a part of meaning, while the rest is conveyed as, e.g., posture, facial expressions (i.e. body language), voice intonation, pauses etc. These factors make communication a complex social process [13].

In general, communication involves a feedback loop between the sender of a message and its recipient (**Figure 1**) [12, 16]. Non-verbal communication, such as

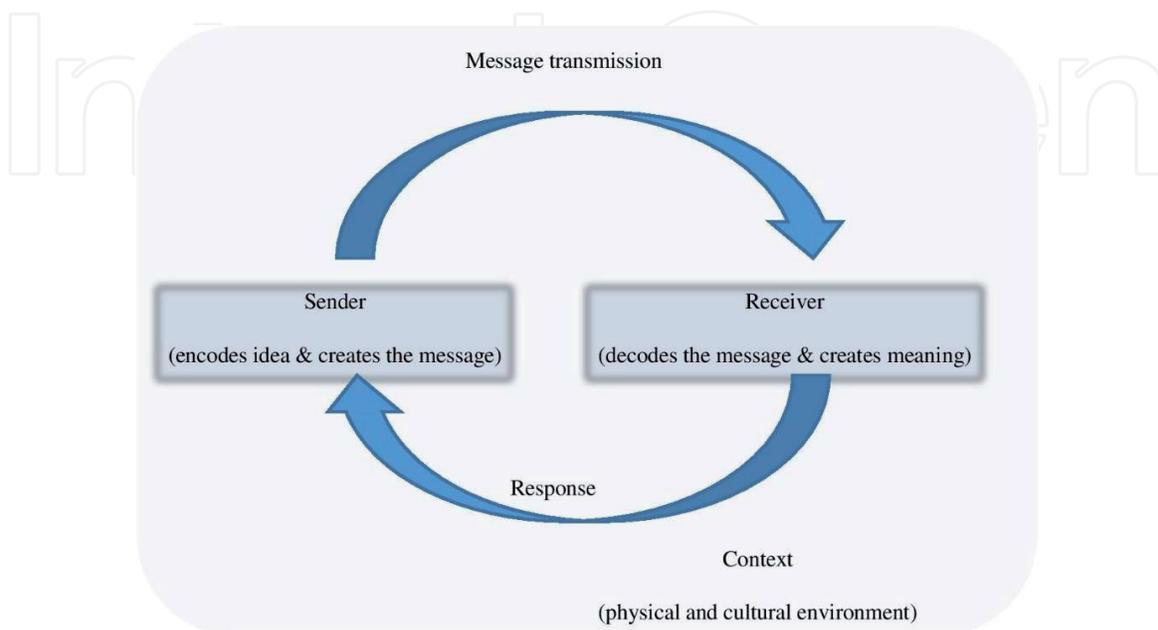


Figure 1.
Transactional model of communication (adapted from [12, 16]).

mimics, plays important role in every physical communication and has to be somehow compensated in virtual environment to keep communication effective. This is even more important, when recipients are from different cultural backgrounds or share different types of expertise. Then a clear, modified explanation is required. To achieve that, as many communication channels as possible (audio, video and textual, etc.) have to be used concurrently and without hesitation [12]. Thus, it is recommended to respond to each message that is distributed among team member in order to know that the message was delivered and that the intent of the message was achieved.

Due to the virtual nature of development teams, most of the work process requires various means of electronic communication [17] and virtual team members have to learn communication skills in order to facilitate virtual NPD. Virtual team members also need to find out ways to express what in a “real” environment is expressed non-verbally [13]. Key challenges in acquiring these skills are geographical dispersion of virtual team members, operation in different time zones, various levels of their technological proficiency, and differences in work-process habits, levels of expertise and cultural differences [14].

Time and place, social presence, and information richness are four dimensions that distinguish different kinds of internet communication tools [14]. The first dimension—time, defines if there are delays between the moments when the information is sent and received, or there is synchronous communication without any delays. The second dimension—place defines the geographic distance between the participants of the communication. Co-located participants communicate at the same place, while dispersed communication is running across different places. The third dimension is social presence and describes the level of possible social sensitivity and personal inter-connections of participants, e.g., allowing nonverbal cues to be communicated along with the verbal message. Information richness is defined as “the potential information-carrying capacity of data”, consequently facilitating personal and immediate feedback. Due to the high level of interactivity, information rich communication tools reduce misunderstanding [14, 18]. Some of the most commonly used internet communication tools are analysed in **Table 1**, according to the above-mentioned four dimensions.

The asynchronous type of communication requires longer period of time to close the message-response loop (**Figure 1**) potentially causing communication noise, delays in process and misunderstandings. For that reason, synchronous types of communication are fostered to facilitate social presence and personal engagement, which are important because they increase personal commitment and ease interpersonal dialogue [14]. Technical improvements of internet communication tools processing and high-speed internet have enabled an effective transition of synchronous types of communication also into the virtual environment [17].

Some researchers claim [20] that humans are not well adapted to asynchronous communication tools regardless to fast technological development of digital communication tools. Kock claims that synchronicity is one of the key elements of media naturalness, especially when communication of knowledge is the goal.

However, despite the rapid development and facilitation of various synchronous internet communication technologies we do not discourage the use of standard face-to-face interaction. On the opposite, number of cases showed that face-to-face meetings, particularly in the early stages of the course or product development process can be useful for team formations, assigning team roles, specifying goals and building initial trust [14]. This was important, as one of the necessary conditions to achieve and maintain a high level of team creativity is the trust among all team members. Research has shown that in uncertain and complex conditions requiring mutual adjustment (which is characteristic for NPD), effective and sustained action is only

Types of communication (tool)	Dimensions			
	Time	Space	Social presence	Information richness
Face-to-face	Same (synchronous)	Same (co-located)	Highest	Richest
Videoconferencing (e.g., Skype-audio-video, etc.)	Same (synchronous)	Different (dispersed)	High	Rich
Audio conferencing (e.g., Skype-audio, conference phone calls, etc.)	Same (synchronous)	Different (dispersed)	Moderate	Moderate
Instant messaging (e.g., Skype chat, Windows live messenger, Yahoo messenger, etc.)	Same (synchronous)	Different (dispersed)	Moderate	Low
Video recorded standup meeting [19]	Different (asynchronous)	Different (dispersed)	Moderate	Rich
Shared workspace (e.g., BSCW)	Different (asynchronous)	Different (dispersed)	Low	Moderate
E-mail	Different (asynchronous)	Different (dispersed)	Low	Low
Voice mail	Different (asynchronous)	Different (dispersed)	Low	Moderate

Table 1.
Types of ICT tools according to four dimensions [17].

possible where there is mutual trust [2, 21, 22]. Similarly, Ijseidoorf (2002, personal communication) found out that personal acquaintances before the beginning of collaboration are regarded as stimulative for virtual teams in industrial environments.

The communication methods and information contents to be shared within teams are in a strong correlation to the phase of the product development process and each of the tasks requires an appropriate ICT infrastructure [23]. However, the results of some studies have shown that the mere availability of ICTs does not necessarily lead to their use and effective/efficient work of the NPD team [24].

Therefore, the certain norms and protocols have to be carefully defined prior to the project start to avoid misunderstandings, unnecessary delays and conflict situations. Norms describe communication behaviour (e.g., availability of team members, acknowledgement of reception of messages, check and response time intervals, frequency of messaging, recipients of various types of information, etc.) [14]. Protocols are more specific and are of operative character on how to use particular ICT tools, who are participants of various sessions and initiators of sessions etc.

According to [14], appropriate balance between structured (i.e. guided by rules) and unstructured (i.e. spontaneous) communication is necessary. Unstructured communication in virtual teams serves as a kind of electronic socialising and is important for, e.g., trust building [4].

Of course, norms, protocols, tools and processes have to be adopted and adapted by the NPD team members to facilitate cooperative work. The almost 15-year history of EGPR course offers us a great opportunity to analyse the evolution of communication tools, norms and protocols used in international virtual teams.

The establishment of communication protocols, which would serve all aspects of NPD process needs, is usually a complex and delicate task, while the final result is usually a multi-layered structure of communication rules serving specific needs of information types, importance and relevance.

3. Evolution of ICT tools for virtual NPD collaboration

The ideas for NPD collaboration in virtual environment, between various partners all over the continent and globe emerged soon after IT communication channels became fast and reliable enough, to support live communication of all project stakeholders and ensure safe and reliable exchange and access to project documents. The EGPR course thus was initiated when all partner organisations had available technical resources to support necessary communication.

The minimum threshold of required resources is rising every year together with development of IT technology and with increase of IP communication channels, but in any case, needs to satisfy these basic communication functions:

1. recorded multipoint professional videoconference system (room) for lectures and presentations;
2. non-recorded multipoint professional videoconference system (room) for project and team meetings;
3. IT tool for real-time slideshow exchange;
4. file exchange system and depository.

All these services have been provided by EGPR partners through all years of the project, as it can be identified from the **Table 2**.

The table shows the constant growth of available internet speed for videoconferences which resulted in more reliable communication, fewer voice and image delays, more frequent use of the VC equipment for communication and increased number of concurrent access points to the conference channels. Namely, in 2009 the project faced initial attempts of joining Videoconferences from personal computers, using H.323 and SIP software to access MCU videoconferencing channels (e.g., ConferenceMe and Ekiga).

After struggling initial attempts and facing a number of technical issues, as connection problems, slow bandwidth, voice echoes, which caused this technology only partially usable, in the last few years the technology allows flawless HD communication from personal computers and mobile devices. This allowed participants to join videoconferences from almost any location. However, although there are no technological obstacles anymore, our experience showed, that the output efficiency of VC meetings declines, when there are too many dispersed participants. The maximal optimal number of different locations concurrently joining the VC is still around 4–5, while there can be several participants at one location. In cases when this number is exceeded, it is obligatory to select skillful moderator who will lead the meeting and maintain strong communication discipline.

In the first 2 years of the project, when only three academic partners were involved in the project, the videoconferencing was hosted at one of the universities (usually at TU Delft) which had equipment, capable of sharing the calls. The larger number of videoconference participants in later years required use of special videoconferencing service and equipment called MCU (Multipoint Control Unit), allowing more participants to join the conference independently—i.e. there is no need for one partner to be available (online) just to host the conference. At first this service was organised by TU Delft, later, since 2009, this service has been provided by ARNES (The Academic and Research Network of Slovenia) (See **Figure 2**). In 2016, the number of concurrent participants was limited to 9 (1 of which is reserved for recording of communication)—see **Figure 3**. Since many of participants tried

Year	No. of partners	VC Bandwidth (Lj)	VC	Presentation sharing	Virtual classroom	Team meetings	Informal communication	File sharing
2002	3	4 × 64 kbit ISDN (256 kbit)	Polycom in Delft	MS NetMeeting, separate PC from VC	TU Delft blackboard	VC	Email, ICQ, MSN	TU Delft blackboard
2003	3	4 × 64 kbit ISDN (256 kbit)	Polycom in Delft	MS NetMeeting, separate PC from VC	TU Delft blackboard	VC	Email, MSN	TU Delft blackboard
2004–2006	4	100 Mbit ethernet	MCU in NL	MS NetMeeting, separate PC from VC	TU Delft blackboard	VC	Email, MSN	TU Delft blackboard
2007	5	1 Gbit ethernet	2× MCU Arnes	MS NetMeeting, separate PC from VC	TU Delft blackboard	VC	Email, MSN, Google chat	TU Delft blackboard
2008	5	1 Gbit ethernet	2× MCU Arnes	MS NetMeeting, separate PC from VC	TU Delft blackboard	VC	Email, Google chat	TU Delft blackboard
2009	6	1 Gbit ethernet	2× MCU Arnes	MS NetMeeting, separate PC from VC	TU Delft blackboard	VC-MCU, Skype	Email, Google chat	TU Delft blackboard
2010	5	1 Gbit ethernet	2× MCU Arnes	Adobe connect (by FSB)	Huddle.com	VC-MCU, Skype	Email, Google chat, Google groups, Facebook	Huddle.com, FTP server (by BME)
2011 and 2012	5	1 Gbit ethernet	2× MCU Arnes	Adobe connect (by FSB)	—	VC-MCU, Skype	Email, Google chat, Google groups, Facebook	FTP server (by BME)
2013	4	1 Gbit ethernet	2× MCU Arnes	Adobe connect (by FSB)	—	VC-MCU, Skype	Email, Facebook, Google chat and groups	BSCW server (UL-FME)
2014	4	1 Gbit ethernet	2× MCU Arnes	Adobe connect (by FSB)	—	VC-MCU, Skype	Facebook, WhatsApp, Google, etc.	BSCW server (UL-FME)
2015	4	1 Gbit ethernet	2× MCU Arnes	Adobe connect (by FSB)	Conceptboard.com	VC-,PC-MCU, Skype,	Facebook, WhatsApp, Google, etc.	BSCW server (UL-FME)
2016	5	10 Gbit ethernet	2× MCU Arnes	Adobe connect (by FSB)	Adobe VOX (by Arnes)	VC-,PC-MCU, VOX, Skype	Facebook, WhatsApp, Google, etc.	BSCW server (UL-FME)

Table 2.
Evolution of IT communication tools and infrastructure used for EGPR course.

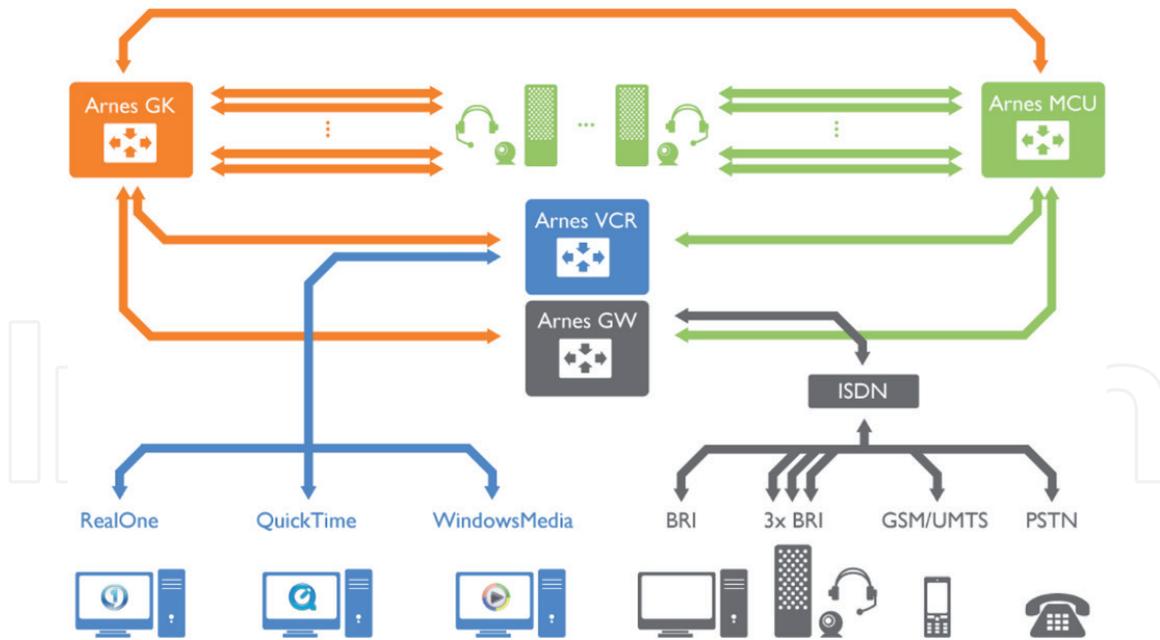


Figure 2.
 ARNES (the academic and research network of Slovenia) ICT infrastructure available for international academic use (source: <https://mcu.arnes.si/portal/>).



Figure 3.
 Example of a lecture at the primary location and simultaneously and interactively broadcast to additional 7 remote locations.

to connect to meetings from their personal devices, this number appeared to be occasionally insufficient and will be raised to 15 VC participants in the project year 2017 in order to ensure access to all.

Hereby, it needs to be emphasised again, that we do not promote the idea of dispersing participants to many locations, however, we want to make it possible in case of necessity. It is necessary to distinguish between the fully interactive lectures and meetings over professional videoconferencing on one side, and must be thus limited to maximum ten participating locations in order the communication to be fully effective—and MOOCs, webinars and video-lectures on the other side, which are usually only one-way or one-and-a-half-way communications, but allows almost unlimited number of participants.

Besides multipoint transmission of live camera picture and voice, it is often required to share computer screen or presentations. EGPR partners tried various solutions for that, including H.239 videoconferencing protocol that enables sharing of the second screen over video professional videoconferencing equipment. However, several problems emerged, when using this standard: most of the professional VC equipment supports receiving the second image, however, only more expensive devices allow also sharing the second screen; the second screen required also broader bandwidth, which was particularly limited in the initial years of the project; H.239 protocol is often not supported in desktop clients, which would limit their usability in case presentations would be shared over H.239 protocol. The H.239 protocol also requires some experienced IT support which was not always available for all project partners. For all that reasons the project partners always used web-based services for presentation sharing. In the first few years of the project, the presentations were successfully shared using Microsoft NetMeeting software, but when Microsoft suspended NetMeeting technical support and upgrades, the EGPR migrated to Adobe Connect service, provided by University of Zagreb, Faculty of Mechanical Engineering and Naval Infrastructure, and has been used so far.

Videoconferences are used daily not only for the lectures, but also for formal and informal team meetings. Weekly formal meetings took place almost as a rule on the professional videoconference channels and equipment. However, in recent years they are also shifting to other services, such as Skype or Adobe VOX (**Figure 4**) as the availability and reliability of these services increased.

On the other side, the informal communication has always been following the most flexible channels available and changed yearly and even within some teams during the same project. Informal communication always acts as a pioneer for exploration of new available technologies and services and often dictates the evolution of formal virtual communication in the future. For that reason, we recommend researchers to carefully observe informal communication also as an indicator of

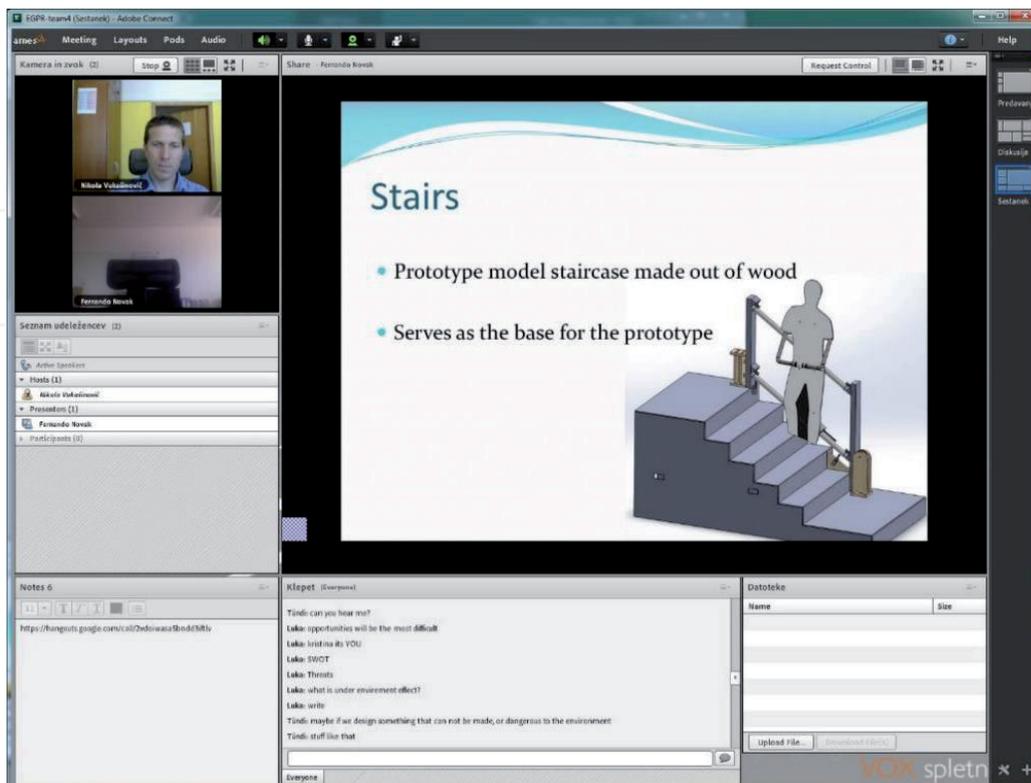


Figure 4.
Adobe VOX system is frequently used for team meetings and presentation sharing.

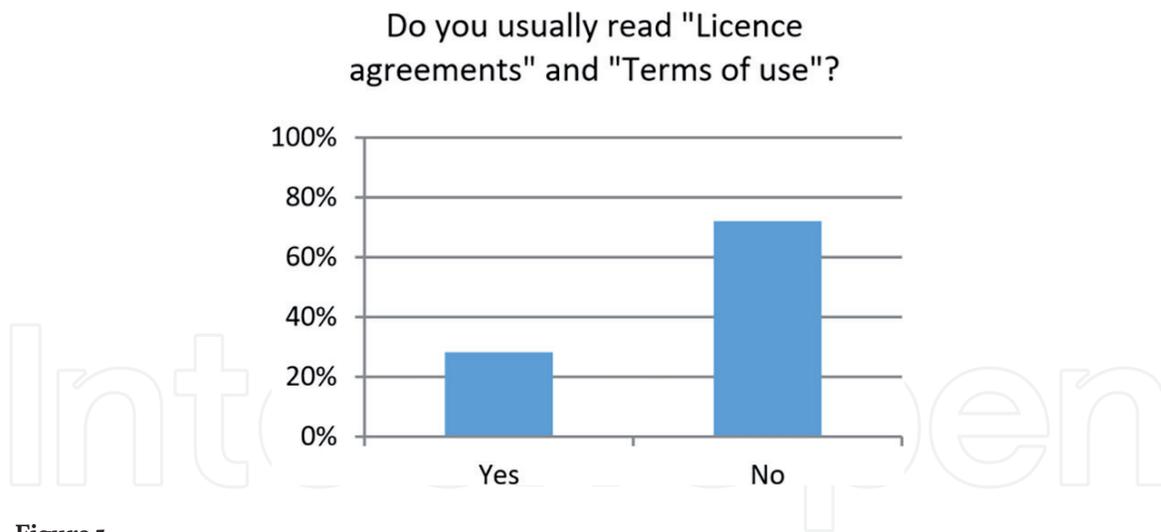


Figure 5. Most of the participants do not read Licence agreements and terms of use, when using internet services.

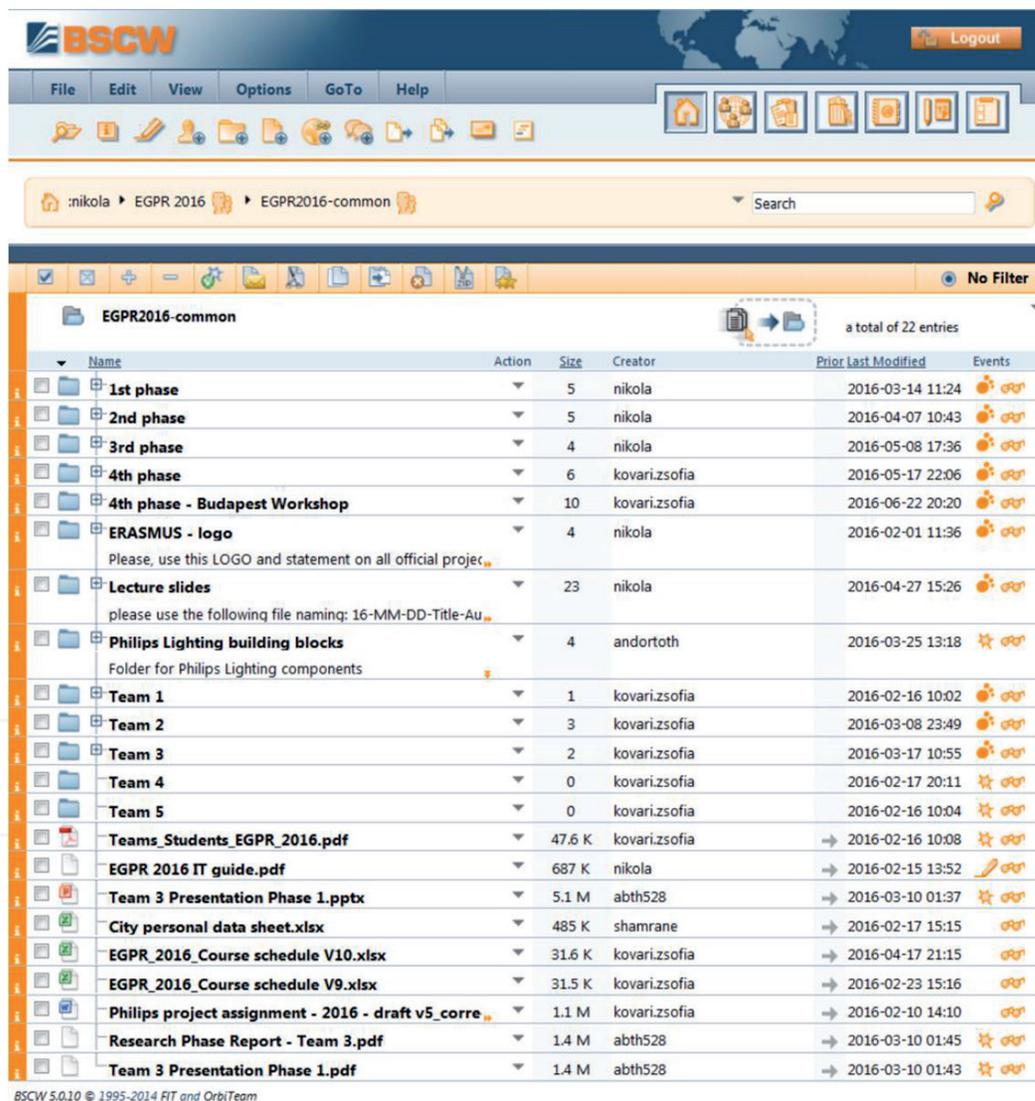


Figure 6. User interface of the BSCW server used for file exchange in EGPR since 2013.

future trends. For the same reason, we also recommend it to keep it deregulated as much as possible; However, it is necessary for all project participants (students and staff) to be constantly aware about intellectual property rights when sharing delicate information over new services. According to one of our surveys [25], more

than 70% of EGPR participants do not usually read Licence agreements and terms of use, when applying for new internet services (**Figure 5**).

Experience showed that the need for regulation of informal communication emerges also when several teams are working on different modules of the same product/prototype. In such cases it is crucial to organise the communication channels and hierarchy (e.g., team leaders, cross-team communication representatives, official document types and versions) for effective communication.

Any NPD project requires also safe storage for deposition and exchange of various sorts of computer documents, e.g., text and graphical documents, spreadsheets, CAD drawings and models, etc. Besides that, it is often required to track versions, changes and to set different access and edit permissions for different users and documents. Through the history of EGPR, these needs were served in various different ways. In the years, when TU Delft was involved in the course, they provided partnership with TU Delft Blackboard system, which included simple file depository and exchange system.

The replacement was needed when TU Delft left the course, so various other systems were tested. At first, remaining partners tried to use a combination of FTP file deposit provided by BME and commercial online collaborative service called Huddle.com. The latter was abandoned next year, as the service showed several limitations of use and high operative costs. Therefore, the partners used only FTP server from BME for all official file exchange and deposition for the next several years until 2013 when consortium started to use BSCW server, provided by UL-FME (**Figure 6**), which completely superseded the needs for the FTP server.

4. Communication in virtual NPD

Our experience from elaborating, organising as well as from running EGPR courses during several consecutive years showed and confirmed that high-quality communication is essential for undisturbed, continuous and successful work in virtual teams. To achieve that communication has to serve as a reliable transfer of clear and meaningful information.

Using technical drawings and equations according to standards and nomenclature are crucial elements to minimise misunderstanding and lack of clarity in communication related to product development process. For example, contemporary CAD modellers provide tools to develop, design, visualise and verify complex 3D parts and assemblies in collaboration (and communication) with other team members. However, focusing too early on too many details, can inhibit the creativity and flexibility that is required to be successful in early stages of the development process or to apply necessary design changes.

The quality of information transfer is another crucial parameter, and requires appropriate local and global IT infrastructure and communication equipment, as well as skilled users or operators. Any kind of interruption, slow or mis-performance or equipment problems (or mishandling) divert attention from communication, and thus having a negative impact on both the quality of discussions and on decision-making [26].

Our experiences from previous courses in virtual collaborative environment have showed that video-conferences are one of the most important tools in the concept generation and concept evaluation phases of new product development process. Based on our experience video-conferences proved to be the best alternative to face-to-face communication for use in virtual teams. This is in line with The

Media Naturalness Theory which sees face-to-face communication as most natural to humans; the theory states that a decrease in the degree of media naturalness of a communication leads to increased cognitive effort and increased level of ambiguity [26, 27]. In the concept generation phase the team members are creating, elaborating and evaluating new ideas. This process is known to require vivid and intensive interpersonal communication, which can only be achieved with co-located face-to-face communication or alternatively with an equivalent virtual communication tool. Some researchers even claim that there is no significant difference between the two of them [14, 28, 29].

In embodiment design or prototyping stage, that is the later stage of product development process, the exchanged information consists mostly of technical facts, resulting in a smaller need for negotiation, argumentation and potential misunderstanding, therefore e-mails can be a main communication channel, while video-conferencing serves mainly for taking final decisions. This is in agreement with other projects carried out by authors [17], where up to 60–70% of all communication was done by face-to-face and Skype (cumulative of both types of communication).

4.1 Trust and the role of informal communication

Trust is defined as an expectation that a partner will act in a way to achieve a positive outcome without the need for control [30]. Additionally, trust encompasses not only people's expectations about others, but also their willingness to use that knowledge as the basis for action [22, 31]. By trust team members can expect their team colleagues will also act cooperatively when they are cooperating [32].

Trust is one of the key ingredients of teamwork, due to its effects on efficiency of an individual team member and a team as a whole. It facilitates collaboration, knowledge exchange and team learning. In short, it affects team performance [32, 33]. Among trusted team members there are no difficulties in idea sharing, no embarrassment in case of "crazy" ideas or even mistakes in work process [22, 34, 35]. Besides, trust also reduces the need for control and supervision, thus lowering the operating costs [22, 36].

Regarding EGPR, product development requires close cooperation between team members; this in turn requires trust. Good communication and creativity also require trust.

Research on trust suggests that trust is a dynamic process with three distinct stages [37]:

1. trust formation: the stage in which team members develop trust over time and start with an initial level of trust,
2. trust dissolution: it occurs when trust erodes as a result of other team members failing to meet a team member's expectations,
3. trust restoration: it can occur when trust stops declining after violation and eventually reaches a relatively stable state.

Al-Ani et al. [32] also observed a fourth stage—a trust adjustment, which occurs when team members adjust their expectations so that they can be met by other team members and it consequently enables trust restoration.

Fulmer and Gelfand [37] defined 6 common and 2 less common dynamic trust patterns (or trust trajectories). The patterns indicate magnitude of changes in trust levels across the formation, dissolution and restoration stages (**Table 3, Figures 7 and 8**).

Trust pattern	Formation stage	Dissolution stage	Restoration stage	Influential factors
High trust	Fast	Slow	Fast	Individual: high self-esteem, secure attachment, locomotion. Social contextual: relationship history, third party and reputation, <i>collectivism within group</i> .
High distrust	Slow	Fast	Slow	Individual: low self-esteem, anxious attachment, cynicism, betrayal aversion. Social contextual: surveillance and monitoring, honour logics, <i>collectivism with outgroup</i> .
Tit-for-tat trust	Fast	Fast	Fast	Individual: tit-for-tat, equity sensitivity. Social contextual: exchange relationship, <i>dignity logics</i> .
Sizing and freezing trust	Fast	Slow	Slow	Individual: need for closure. Social contextual: time pressure, <i>power distance with authority</i> .
Assessment trust	Slow	Slow	Slow	Individual: assessment, need to avoid closure. Social contextual: public situation.
Grim trigger trust	Fast	Fast	Slow	Individual: grim strategy, interpersonal orientation. Social contextual: <i>performance orientation</i> .

Table 3.
Basic characteristics of 6 common dynamic trust patterns (adapted from [37]).

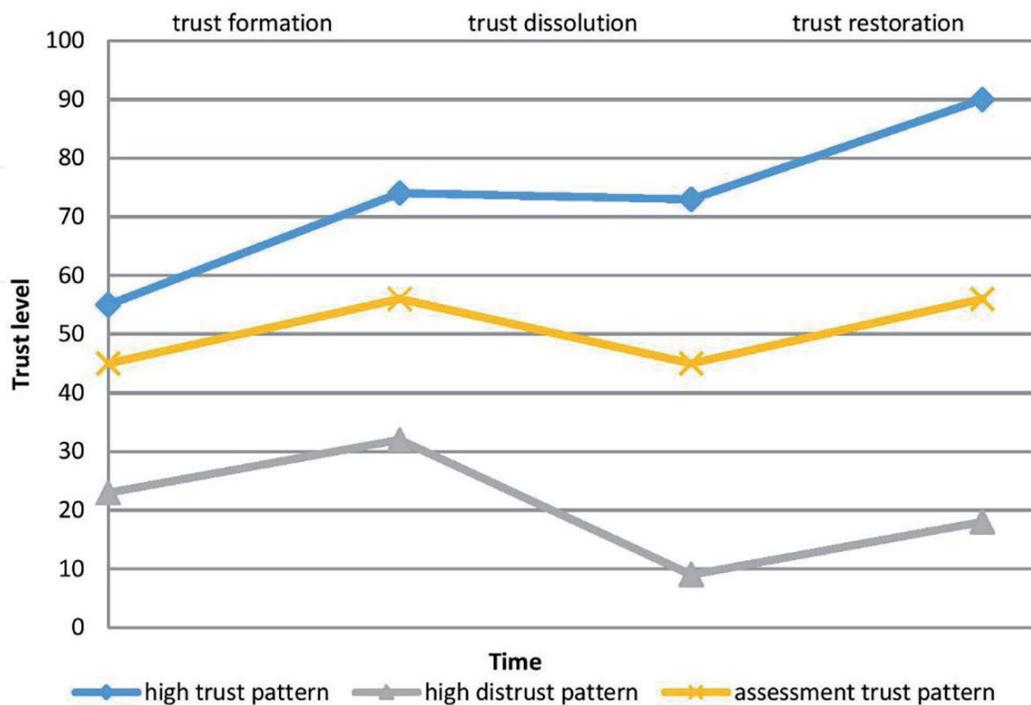


Figure 7.
Trust patterns (adapted from [37]).

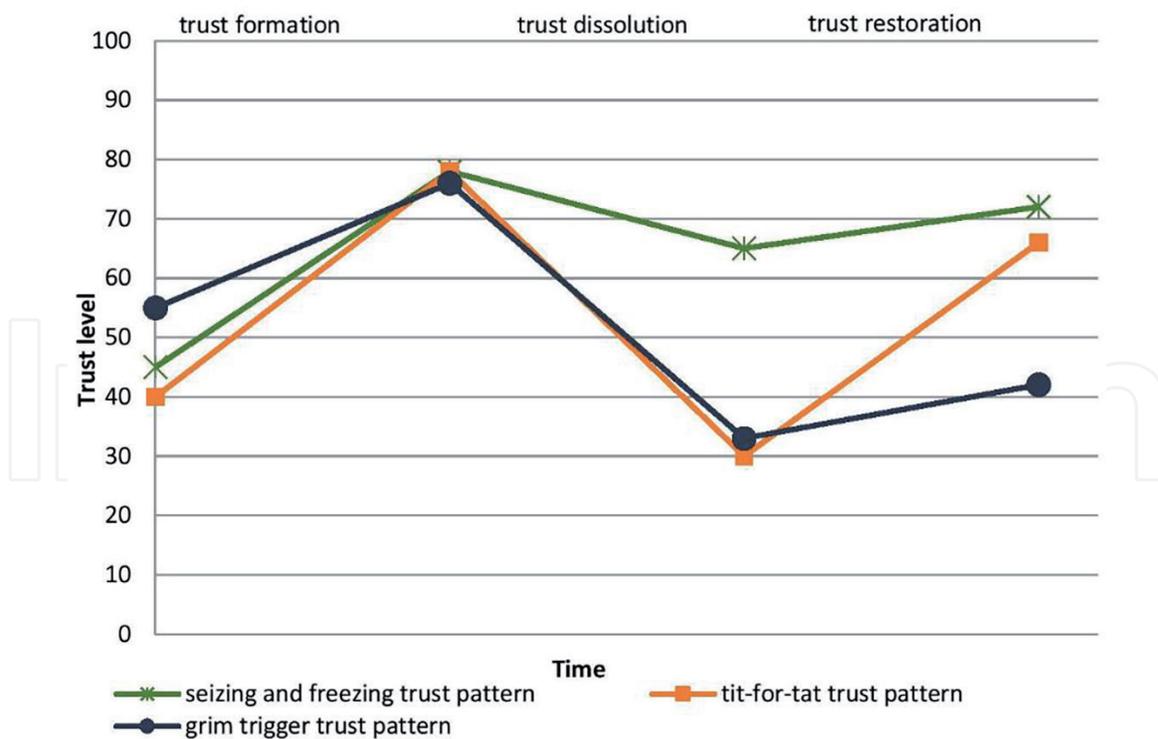


Figure 8.
 Trust patterns (adapted from [37]).

They further identified and explained individual and social contextual factors characteristic to trust patterns, and focused also on the important role of cultural dimensions, such as [37]:

honour: trust restoration following trust violations in honour cultures is expected to be very slow and difficult. Trust formation is also expected to be slow, because members of honour cultures are strongly concerned in the competences and benevolence of the trustee than other cultures;

dignity: members of dignity cultures generally form trust fast, because they believe that dignity is inherent in all human beings. However, they are also sensitive to trust violations, which leads to fast trust dissolution;

collectivism: collectivists tend to perceive their ingroup members to be trustworthy, which should lead to fast trust formation. On the other hand, due to distrust of outgroup members, trust formation can be slow;

power distance: members of high power distance cultures expect the authority members are competent and benevolent, therefore trust formation is expected to be fast. In case of trust violation of authority member, trust restoration would be slow and difficult, especially when subordinates were highly committed;

performance orientation: members of performance-oriented cultures should be fast in trust formation, due to sense of urgency created by performance orientation. The members are also responsive to trust violation, meaning that trust dissolution is fast and restoration slow.

Cultural dimensions of trust process are of high relevance for global virtual teams.

For trust to develop, it is necessary for team members to share a common history and have personal contacts; this is what trust within development teams at a single location (i.e. collocated teams) is built on. However, in the case of EGPR project teams and often in professional product development teams this is not possible, because projects have to be finished in a limited time frame. In such circumstances, virtual teams have no time to build interpersonal relationship. Additionally, EGPR team members will very unlikely work together in the future.

Therefore, it is necessary to start with initial, swift trust and build on it. Swift trust is trust that is formed around a common task with a short time span (e.g., product development projects within EGPR) [38]. It is based on team members' background, competences and affiliations, and not on past experience (i.e. common history); swift trust provides necessary initial confidence for team members to interact [38, 39]. In their research Jarvenpaa and Leidner [38] categorised major characteristics of studied virtual teams regarding communication behaviours that facilitated trust early in a virtual team's life:

Social communication: initial communication among team members beginning with high trust was mainly social. Similarly, in Ref. [19, 40] found high number of social talk/cheap talk messages at the beginning of a virtual team lifecycle. Teams with low initial trust exchanged only few social messages. Team members of successful teams were careful not to use social communication as a substitute for task progress;

Communication of enthusiasm: for the teams with high initial trust high content of enthusiasm was characteristic for their messages, while teams with low initial trust communicated low contents of enthusiasm.

This portion of trust, which is built initially and serves as the basis for further consolidation of trust via appropriate communication, is what team members can rely upon most [12, 38].

Later, trust can and needs to be consolidated through predictable communication, quick responses and individual initiative, because the swift trust is fragile and temporal. Communication behaviours that helped maintain trust later in a virtual team's life are [38]:

Predictable communication: irregular and unpredictable communication patterns hindered trust. Announcing communication absences additionally contributed to confidence in team members' commitment. Regularity in communication was very important. Frequency of communication alone is of lesser importance [33, 41];

Substantive and timely responses: thorough evaluation of contents and prompt responses to messages were the key factors of trust maintenance. The senders were confident that their contributions to project tasks were appreciated, elaborated and reflected upon. Superficial evaluation or even lack of any response signalled low commitment and consequently erosion of trust.

Similar characteristics of initial trust and trust maintenance were also found by e.g., [36, 42]. Al-Ani et al. [32] found that richer communication media (i.e. video conferencing) are better for trust development than leaner (i.e. e-mails).

Regarding research of trust building and its maintenance, researchers have used various perspectives. For example, Ref. [40] used a novel cost-benefit perspective, rather than a social relationship one. They found that the team members that engaged in their internal communication in so called cheap talk (i.e. non-work related conversation behaviour), generally have higher trust. This is interesting since some economics literature claim that such non-work related communication is meaningless and a waste of time [40].

Due to key importance of communication regarding virtual team work appropriate norms that describe communication behaviour (e.g., availability of team members, acknowledgement of reception of messages, check and response time intervals, frequency of messaging, recipients of various types of information, etc.) were defined and disseminated to virtual teams prior to each year's EGPR project start. Norms promote adaptive and effective behaviour by providing guidelines for acceptable and unacceptable behaviour [33, 43]. For example, [33, 44] found that externally induced communication rules boost trust in a virtual team. Similarly, Saunders and Ahuja [45] cited in [33] believed that normative actions related to technology and communication facilitate goal achievement and increase the overall productivity of the team.

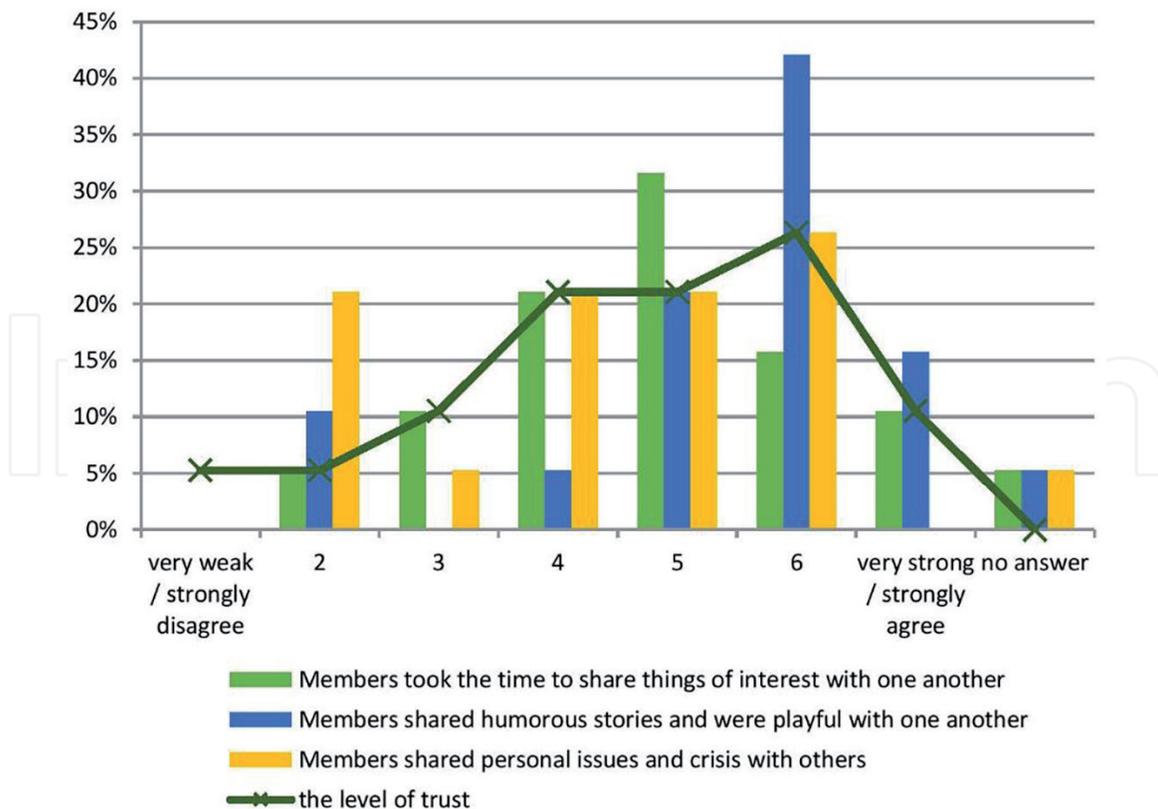


Figure 9.
 Chart showing the level of trust among team members and the activities necessary to build personal bonds between team members [5].

For example, **Figure 9** shows the rate and structure of informal information shared among EGPR team members (columns) as well as among them. Comparing the results, one notices their congruity. The trust among the members was relatively strong, although some people did not want to share private details (personal issues, crises or things of interest). However, there was still a lot of impersonal, non-task related communication among the participants, which also served for socialising and trust building.

Socialising in virtual teams facilitates creation of trusting relationships between EGPR team members. It is very important and complicated to perform as there is no personal contact between team members, which means that greater efforts are required for the development of interpersonal relationships within the team, which consequentially increases the need for communication—electronic socialising. This is done mostly by exchange of personal or non-professional information, such as hobbies, movies they watch, music they like, sports they practice, exchange of personal photographs, travelling preferences, concern for others etc. [4, 19, 32, 35, 40, 46–48].

5. Communication trends (future) in virtual NPD teams

Collaboration in virtual teams has been established in many industries such as software development, electronics, etc. but also in science and research. It is a modern and flexible organisational form, which allows cooperation of various geographically dispersed experts, who can join the teams at the beginning of the project, or only when their knowledge and expertise is needed and leave afterwards. This form of collaboration became possible with the development and availability of adequate computer and IT technology, but requires also some knowledge and experience from the users. This form of organisation was implemented also in many

engineering courses. One of the earliest such courses is European Global Product Realisation, which aims to teach students of real industrial experience of new product development in virtual environment already since study year 2001/2002.

EGPR can be seen as a unique example of continuous evolution, development and increasing availability of IT infrastructure and software for communication, sharing of documents, organisation of work and cooperation. At the same time the knowledge about work in such organisational entities increased and matured. Hereby EGPR provided good opportunity to implement new practices, obtain our own experience and to test other's results.

Good communication flow is crucial factor for NPD process to be successful and well timed. This chapter has covered various aspects of communication in virtual environment, and given insight into the evolution of 15 years long project and provided generalised directions to make collaboration in virtual environment successful. Communication, however, is not only dull exchange of professional information, but a complex interaction between numbers of individuals with unique personal characteristics. Therefore, it is crucial to develop sufficient level of trust among all project participants. One can say, trust is along with team members' technical competences basically a fundament, which ensure efficient work and successful completion of the project.

Interpersonal communication basically consists of verbal exchange of messages, intonation, facial expressions and body language. There has been a lot of research to evaluate the importance of each component of personal communication, e.g., [49, 50] or [51], however all researchers agree, that words represent only a fraction of interpersonal communication. Communication in virtual teams using various sources of information transmitters therefore filter some components of interpersonal communication. E-mails facilitate exchange of words only, telephone and Skype calls facilitate exchange of words, voice and intonation, while video calls support exchange words, voice, intonation, facial expressions, but majority of body language remains concealed even when communicating over best video conferencing systems. As the team members being geographically dispersed, often also with different cultural background and field of expertise, makes the process of information exchange even more difficult and delicate.

Due to all these limitation of communication in virtual environment we recommend to follow some basic rules for effective NPD in virtual environment. These rules were developed based on our research, practical experience from organising EGPR course, personal testimonies of students, coaches and industrial representatives and analysis of various questionnaires:

If possible, organise kick-off face-to-face meeting at the beginning of the project, for all team members;

It is necessary to introduce all ICT tools which will be used for the project and test/improve knowledge and competences of user's/team members for uninterrupted use during the project. It is also crucial to facilitate compatible infrastructure and maintain its service and support at all project locations during the whole project's lifetime;

Set the communication rules and protocols before the official project start;

All team members must be well aware of cultural and personal differences and of the importance of trust building;

Leaders of virtual teams must be aware of and allow and encourage informal communication (i.e. cheap-talk). It is recommended to allocate and dedicate particular time and meetings for that in order to keep working meetings effective;

Informal communication should not be limited to formally defined communication protocols and ICT tools. It should stimulate the use of new and alternative ICT tools.

All these rules are derived from our 15 year long experience from organising EGPR academic–industrial courses which we believe to be a good analogy to real industrial virtual team cases.

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