

Barriers to Creativity in Distributed Product Development

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Abstract

Processes involving creative problem-solving are known to be challenging for distributed teams. To better support product development teams working in distributed settings with their creative processes, the positive and negative influences on creativity need to be known and understood. This contribution focuses on delivering a broad understanding of specifically the barriers to creative problem-solving. To reach this goal a systematic literature review was carried out where 418 initial results were found and then systematically broken down to the 49 most relevant results. 47 barriers were identified, analyzed and integrating into an impact model that now shows not only success factors but also barriers to creativity. With the impact model at hand, targeted support can be created to overcome the challenges distributed teams face when it comes to creative processes.

Keywords

Creativity, Distributed Product Development, Virtual Teams, Creative Problem-Solving and Barriers to Creativity.

1. Introduction

Product development is nowadays a process that often takes place in a distributed setting. Employees are scattered all over the world, forming multinational teams. The flexibility that comes with the distributed work setting as well as the opportunities that come with working from home and with international team colleagues are part of the umbrella term “New Work” (Helmold 2022). These aspects and many more have an influence on the creative problem-solving process of the team (Bastian et al. 2023). Activities for which creativity is needed have been identified as critical within distributed product development teams. The distributed setting and especially the communication via technical communication assistance instead of face-to-face hinders the joint development of creative ideas (Brucks and Levav 2022). After the success factors for creativity in distributed product development teams have already been studied in depth (Bastian et al. 2023), this paper’s goal is to generate a comprehensive understanding of the barriers to creativity in distributed product development.

1.1 Current Understanding

1.1.1 Distributed Product Development

Product development is defined by the VDI as a corporate process for developing a marketable product through an interdisciplinary team. Hereby, product development is an iterative process where the initial goals and requirements for the product in development are continuously adapted (VDI Verein Deutscher Ingenieure e.V. 2019). Furthermore, product development is seen as a dynamic, complex and multi-faceted process where people, a product under development, associated processes, knowledge, methods and tools in an organizational, micro- and macroeconomic context build the relevant elements (Blessing and Chakrabarti 2009). Therefore, product development is not only dependent on the product itself, but many aspects play an important role in supporting product development.

Product engineering can be seen as the iterative development of three different subsystems (Albers et al. 2011) based on the system theory by Ropohl (1975). The system of objects is developed to comply with the objectives that are specified in the system of objectives. All the objectives as well as their interrelations are noted within the system of objectives. Requirements and boundary conditions are included as well. Within the system of objects, the results (final product) and intermediate results (e.g., prototypes) are collected. The system of objects is developed to meet the requirements defined in the system of objectives. The operation system consists of the necessary resources. Creativity techniques are included within this subsystem, as well as financial resources, computers and technical equipment as

well as engineering and engineers themselves. The connection between the system of objectives and the system of objects is made through the operation system. (Albers et al. 2011).

For efficient engineering and communication, an efficient operation system is needed. Therefore, the operation system needs to be developed to be able to communicate and cooperate across different locations with the increasingly distributed partners whilst the resources within the operation system are increasingly distributed as well. “Distributed product development describes the form of product development in which collaboration in the activities is characterized by at least one individual being spatially separated from the other individuals. The geographic separation can be extended to organizational and temporal separation. Information and communication technologies (ICT) have to be used for collaboration. Collaboration can take place both synchronously and asynchronously.” This definition by Albers et al. (2022) is the understanding of distributed product development that builds the basis for this work. Within this definition, not only the special characteristics due to the technological support needed for distributed product development are included, but other aspects are taken into account as well. To support distributed teams, different methods have been developed with a focus on different elements of distributed teamwork. With the Virtual Team Maturity Model (Friedrich and Keil 2017), the PCM-Model for describing collaborative design (Bavendiek et al. 2017) and the EDiT method – Enabling Distributed Teams (Albers et al. 2022) relevant methods for supporting distributed teams can be found but so far without a focus on creativity.

1.1.2 Creativity in Distributed Product Development

As already mentioned above, tasks that involve creativity are especially challenging for distributed teams (Brucks and Levav 2022). But creativity is an aspect that is highly relevant for successful product development independent of the setting in which the team works (Stempfle and Badke-Schaub 2002).

In general, creativity is associated with developing something that has not been there before, the creation of something new (Bender and Gericke, 2021). Whatever has been created, does not necessarily have to be useful within the general understanding of creativity. Creativity can be divided into primary and secondary creativity. Primary creativity brings out an output that can be considered as highly creative. It does not necessarily have to fulfill a use in the short term, nor does it need to be directly purposive. The output of primary creativity has, once it is developed further, the chances of being an innovation that replaces a prior product or service. The information basis in such a development process is usually low. The product properties of a product resulting from primary creativity are not clear during the start of the development process leading to the solution space being barely limited. Furthermore, the goals for the costs or quality of the product are not fully known. Secondary creativity on the other hand leads to ideas with a lower degree of novelty but a short-term focus. The output of secondary creativity usually has a lower development risk and can be implemented fast. Secondary creativity comes into play for the further development of existing solutions and products and leads to incremental innovations. (Bender and Gericke 2021; Deigendesch 2009).

1.1.3 Influencing Factors on Creativity in Distributed Product Development

The influencing factors on creativity in distributed product development can be categorized into seven categories: *Team, Individual, Organization, Leadership, Culture, Technology* and *Time*. Within those categories, 72 success factors have been found in an extended systematic literature review. 14 barriers have been identified as well, most of them in the categories team and culture but with the research focus being success factors, there are a lot of barriers still to be found. The factors can be modeled in an impact model, showing that there are interconnections between factors and between categories as well. The success factors and barriers are highly interconnected, showing that the impact on creativity in distributed teams is versatile and complex. *Different language* (Ivanaj 2016) and *different background* (Hu et al, 2017) are some of the barriers identified already (Bastian et al. 2023).

To support distributed creativity the focus of this paper is identifying further barriers as a basis for developing support for overcoming these barriers and enhancing the success of creative problem-solving processes in distributed teams.

2. Research Profile

2.1 Research Goal and Research Questions

Product developers can benefit from a great variety of existing methodical support for distributed product development, but the difficulties that arise when working on tasks that involve creative problem-solving still exist when working in a distributed setting.

The success factors for creativity in distributed product development have already been searched for and brought together in an impact model (Bastian et al. 2023). The model shows not only the variety of factors but makes a categorization possible and shows the interconnection between factors and categories. The existing barriers on the other hand have still to be found in the various literature describing the negative influences on creativity in distributed product development. So far only 14 barriers have been identified leaving the identification of further barriers to be the research goal of this submission. This research is delivering the collection of barriers not with the claim of completeness but as a basis to be permanently extended. Adding the barriers to the existing list and model with the success factors is an appropriate starting point for developing support specifically for creativity in distributed settings.

This research is structured by the following research questions:

RQ2: What are the barriers to creativity in distributed product development teams?

RQ3: How are these barriers interconnected?

RQ4: How can the existing impact model be further developed to include the barriers and their interconnections?

2.2 Research Approach

For answering the research questions a systematic literature review has been carried out using the following databases: Google Scholar, IEEE, Scopus, Web of Science and Design Society. A variety of search strings combining creativity, distributed product development and barriers have been used. The respective synonyms in English and German have been included as shown in *Table 1. Systematic Literature Review: Search Strings*. To carry out a precise search the search strings were adapted according to the requirements for the different databases. An exemplary search string used in Scopus is "creativity" AND "barriers" AND "distributed product development". For achieving a manageable amount of search results within the Scopus database, the search has been carried out only in the fields "article title, Abstract, and Keywords". Due to the high number of search results, Google Scholar has been used for a specific search for *technical creativity* in German language. In this case, the limitation of search results over the year of publication was not considered expedient, as older results on technical creativity might be as relevant as newer results since technical creativity is not limited to the distributed context. The terms combining barriers and creativity were used as well in Google Scholar, but only in German, again to be able to achieve a manageable number of results. With 266 results, Google Scholar provided more results than any other database, even after limiting the search results. From all five databases 400 results have been obtained and after analysing the references used in these publications, 18 additional relevant publications have been identified, leading to a total of 418 results, the majority from Google Scholar. After eliminating the duplicates, 369 results remained. To identify the most relevant publications, the results were further sorted through manual checking of the relevance of the title and abstract. The remaining 49 publications were then analysed to find barriers to creativity in distributed product development teams. In total, 47 barriers have been identified through the analysis of the results obtained. The barriers were allocated to the seven categories: Team, Individual, Organization, Culture, Technology, Leadership and Time identified by Bastian et al. (2023). Furthermore, the literature was analysed for interconnections between the different barriers, to be included in the impact model as well.

Table 1. Systematic Literature Review: Search Strings

English	(technical) Creativity	Barrier	Distributed product development
		Limits	Distributed product development
			Virtual teams
			Collaborative engineering
German	(technische) Kreativität	Barrieren	Produktentwicklung

3. Barriers to creativity in Distributed Product Development

Based on the systematic literature review, 47 barriers to creativity in distributed product development have been identified. Not only do these barriers influence creativity in distributed teams, but the categories themselves have influences on each other and some barriers have influences on other barriers as well. In the following, the barriers found in the literature are presented in detail and allocated to the categories as presented in Bastian et al. (2023). The

seven categories are: *team* with 11 barriers, *individual* with 12 barriers, *technology* with five barriers, *organization* with 10 barriers, *culture* with four barriers, *leadership* with three barriers, and *time* with two barriers

3.1 Barriers to Creativity in Distributed Product Development in Detail

Team

Group size: If poorly managed, excessive team size can harm creativity as cohesion becomes more challenging and "social loafing" is more easily facilitated. A higher number of members leads to difficulties in regard to operation and communication, especially if it comes with a bigger number of distributed members. (Abi and Agogu  2023; Leenders et al. 2003).

Diversity: A necessary distinction exists between functionally diverse teams, which can have a positive impact on the creative performance of virtual teams, and "deep-level" diversity, which can trigger a contrasting effect. Deep-level diversity describes profound characteristics in, for example, attitudes, values, beliefs, and opinions. (Abi and Agogu  2023).

Group structure: When a team consists of individuals who are too homogeneous in terms of educational background, experience, cultural origin, age, and gender, it tends to work ineffectively. This is because it lacks diverse perspectives within the group, which inhibits the generation of new ideas. In contrast, in heterogeneous teams, it can be challenging to reach a common consensus due to the diversity and differing viewpoints within the team. The potential for conflicts is conducive to the emergence of innovative and creative ideas, but the extent of conflicts plays a crucial role: creativity in heterogeneous teams initially increases with growing conflicts, yet it decreases again when conflicts become too strong. (Hubounig et al. 2013; Leenders et al. 2003).

Normalization: Normalization refers to the mutual influence among group members, leading them to be willing to compromise. While normalization can be an indicator of shared understanding within the group, it can also represent the outcome of conflict avoidance leading to the team lacking different ideas. (Ocker 2005).

Groupthink: Groupthink describes the urge within a group to reach a consensus by avoiding or suppressing deviations from the group's opinion. Therefore, groupthink inhibits effective group discussions and leads to the avoidance of conflicts and disagreements on a personal level (Hubounig et al. 2013; Ocker 2005).

Group dependency: Fear of evaluation describes individuals' apprehension about being judged by other members when sharing their ideas. A dependency on the other team members that is expressed for example in such a way leads to negative effects for the teams as a whole. (Hubounig et al. 2013; Ocker 2005).

Conflicts: Conflicts, depending on their intensity and the personalities involved, lead to a loss of trust and distractions, which in turn contribute to reduced information exchange and low group cohesion. (Andriopoulos 2001; Hubounig et al. 2013).

Dominance: In teams with strong dominance by one individual, an environment of control and conformity is created. This impairs interaction among team members, causing certain individuals to automatically take a backseat. (Ocker 2005).

Communication: In virtual teams, communication is often limited to a factual level. It's important to recognize that reducing employee communication to purely factual content overlooks the fact that factual communication is inseparably linked to interpersonal communication. *Communication frequency*, *centralization* and *formality* are separate barriers on the same topic. There are pictured together within the overview of Figure 1 and separate in the detailed view in Figure 2. Too high and too low levels of communication frequency can harm creative performance. Centralizing information to certain individuals in the team reduces the autonomy of other team members, which is essential for individual and team creativity. A high level of communication formality can reduce communication frequency and can increase the level of centralization. (Leenders et al. 2003).

Membership duration: It has been observed that team creativity decreases with the increasing duration of team membership. The longer the composition of a team remains unchanged, the lower the level of creativity tends to be. (Leenders et al. 2003).

Subgroups: The creative development of individual employees is at risk when subgroups excessively compete with each other, or when communication among them suffers. (Chamakiotis et al. 2013).

Individual

Personality traits: The most important personality trait for creative achievements is openness. Openness to new experiences refers to individuals who are receptive to new ideas and consider unconventional methods. They are adventurous and willing to try new things without a team member with this personality trait the innovative potential of a team suffers. (Abi and Agogué 2023; Hubounig et al. 2013).

Cognitive abilities: A higher intelligence doesn't automatically mean that an individual is more creative, but it has an impact on the potential and the likelihood of the upbringing of creative achievements. Lacking the appropriate cognitive abilities has a negative influence on creativity on an individual level. (Hubounig et al. 2013).

Motivation: Certain ways of achieving extrinsic motivation can negatively influence motivation for certain team members. A low level of motivation or a diminishing level of motivation poses a barrier. (Hubounig et al. 2013; Ocker 2005).

Domain knowledge: A low level expertise within the domain harms the potential to generate a creative idea. (Ocker 2005).

Downward normalization: The absence of incentives can lead to the occurrence of a downward normalization where team members lower their performance to the level of the weakest employee. In groups of this kind, insufficient communication and efforts have often been observed. (Ocker 2005).

Design fixation: Design fixation refers to a condition in which designers and developers are unconsciously influenced and constrained in their creative process by existing knowledge, ideas, and assumptions, leading to being stuck on existing ideas. (Gonçalves 2018).

Usage of search engines: Studies show a lack of ideas after the use of search engines due to unmet expectations. When the expectations are not met, individuals tend to stop looking for information entirely and reduce the process of searching for relevant information to a minimum leading to relevant information for solving a task to be missing. (Gonçalves 2018).

Social loafing: Social loafing refers to individuals exhibiting less effort and willingness when they work in groups or on cooperative tasks compared to when they work alone and rely on the work of others. (Abi and Agogué 2023; Hubounig et al. 2013).

Receiver barriers: Receiver barriers describe the incapability of an individual to recognize opportunity or problem early on leading to frustration and as a result less creative output. (Gonçalves 2018; Mensel 2013).

Value barriers: Barriers of this nature describe the inhibition of creativity due to an individual's own or induced value perceptions not being compatible with the company's values. (Mensel 2013).

Self-perception barriers: Some individuals are extremely fearful of potential resistance to their idea within the organization leading to not wanting to propose creative solutions. (Mensel 2013).

Technology

Media selection: Using an inappropriate medium (text, e-mail, phone call) can lead to a production blockage. (Abi and Agogué 2023; Grözinger et al. 2020; Handke and Kauffeld 2019).

Asynchrony: Asynchrony leads to time losses due to the reading and interpretation time that is required for example with text messages. Follow-up inquiries are perceived only after a delay, thus slowing down the entire process, particularly when there is high task interdependence. (Abi and Agogué 2023).

Technical issues: There are various obstacles to contributions in virtual teams, such as unstable internet connections, lack of access to the server, or the inability to read attachments from other members due to incompatible versions of word processing software. (Ocker 2005).

Limited visual view: When working with virtual teams, the visual view of each person's screen is limited. This restriction of visual perspective has been shown to result in cognitive limitations, particularly impacting the generation of ideas. (Brucks and Levav 2022).

Organization

Organizational culture: Organizational culture refers to the shared values, beliefs, and behaviors that are embraced by members within an organization. It influences the thinking process and actions of employees and can be seen as a barrier to creativity, as employees are bound and rooted by the culture. This makes it challenging to break through established thought patterns. In addition to that, certain norms can harm creative performance: a direct and controlling environment, high conformity, and a culture characterized by punishments are, in contrast to a risk-taking environment. (Andriopoulos 2001; Hubounig et al. 2013; Krause 2013; Verburg et al. 2013).

Technostructural subsystems: Technostructural subsystems encompass established procedures, programs, reward systems, as well as control and communication systems that are tightly integrated into the organization and familiar to its members. This results in a certain resistance when introducing innovations. (Hubounig et al. 2013).

Stiff hierarchy: A stiff hierarchy blocks creative performance through inflexible communication and the lack of autonomy for individual employees. (Hubounig et al. 2013).

Task dissection: The decomposition of components into partially independent sub-components in product development processes can lead to coordination challenges, as it increases the centralization of communication and raises the communication frequency within subgroups while reducing it between subgroups. Consequently, creative performance is diminished in tasks that require collaboration among different teams. (Leenders et al. 2003).

Overload: Developers identified overload as one of the main factors contributing to creativity-inhibiting performance. Nowadays, most projects are subjected to tight deadlines, often resulting in solutions that are timely rather than optimal. (Salter and Gann 2003).

Control and coordination issues: The roles of team members in activities related to technological innovation can vary significantly, leading to control and coordination challenges. Applying the same control mechanisms to different tasks is not ideal and can distort the measurement of creative performance, making it difficult to incentivize creative tasks which leads to a loss of motivation. However, employing different control mechanisms gives rise to coordination difficulties. Managing and controlling creative processes can be problematic as they negatively impact employees' motivation and flexibility. (Berhausen and Thrane 2018).

Spatial Dispersion: A significant spatial dispersion of team members can lead to communication difficulties and increase the likelihood of asynchronous communication. Furthermore, the effectiveness of individual members might suffer due to the superficial nature of relationships. Globally distributed teams are likely to consist of members from various cultures, making the establishment of a shared understanding more difficult. (Verburg et al. 2013).

Financial resources: A certain level of financial resources is necessary for the expression of creativity as e.g., experiments in product development must be conducted and potentially repeated. Additionally, employees often associate the available budget with the importance of the project, so insufficient funds could diminish motivation. (Andriopoulos 2001).

Political issues: Political issues within a company can create communication barriers, hinder trust, diminish employee motivation, and negatively impact team dynamics and collaboration (Andriopoulos 2001).

Culture

Cultural differences: The existence of cultural differences poses a barrier to developing a common understanding of team roles and tasks and various group identities can collide. However, for the formation of a shared consensus, identification with the group to some extent is crucial. This barrier is in a distributed setting even stronger since the

virtual space limits the discovery of cultural differences and getting to know a team member's culture. (Köppel 2009; Seus 2020; Verburg et al., 2013; Wessely 2012).

Language differences: Differences in language, communication style, and the interpretation of messages can lead to misunderstandings and conflicts. They can result in errors, delays, and reduced productivity and effectiveness. As a result, essential prerequisites for establishing a foundation of trust, which is necessary for good creative performance, are absent. (Köppel, 2009; Seus 2020; Verburg et al. 2013; Wessely 2012).

Different expectations: The collaboration of intercultural team members is hindered by varying notions and expectations regarding aspects such as punctuality, flexibility, group harmony, leadership, and work methods (Köppel 2009).

Conflict solving: In teams comprised of employees from different cultures, it is challenging for individuals to assess their colleagues, as the pursuit of a personal relationship and the notions of an effective team can vary significantly. Resolving conflicts, therefore, requires more time and a variety of perspectives and approaches. (Köppel 2009).

Leadership

New leaders: The increasing shift towards virtual work presents leaders with the challenge of maintaining employee engagement, trust, and motivation. In virtual work environments, the direct personal interactions that occur in physical offices are absent, making relationship-building and team cohesion more difficult. (Abi and Agogué 2023).

Reduced sharing of information: In virtual teams, the exchange of information is often limited to factual matters. The perception of limited opportunities to also share information on an interpersonal level can have a negative impact on the motivation of individual members and foster conflicts. (Brinkmann et al. 2022).

Management: Management can inhibit creativity when ideas are prematurely suppressed, there is a lack of tolerance for errors and risk-taking or when feedback is inadequate. (Hubounig et al. 2013).

Time

Time zone difference: Asynchronous technologies are frequently utilized when time zone differences separate the team. However, the resulting time delays due to extended communication durations impair the effectiveness of work processes. Employees may find themselves working or being available around the clock. (Bhusari et al. 2007; Wessely 2012).

Time pressure: Strict deadlines can lead to restricted thinking and a loss of quality, as often the next best solution is accepted and refined. Furthermore, to maintain a certain level of creative standards, time is needed for activities like experimentation. (Ocker 2005)

3.2 Impact Model

To show the categories and influencing factors and how they are influenced by each other an impact model was created by Bastian et al. (2023). The impact model has now been supplemented with the above-mentioned barriers within the associated categories.

The model is divided into two levels. The first level, as shown in *Figure 2: Success Factors and Barriers to Creativity and Interconnections between Categories based on (Bastian et al. 2023)*, includes the influencing factors and barriers of each category. The barriers are hereby depicted in the redly framed part of the combs. Furthermore, there is a total of 15 interconnections between the categories. For example, *Team* and *Individual* influence each other as groups consist of a sum of individuals which leads to team creativity being influenced by the individual creative performance of every member. Additionally, team members have varying personality traits and harmonize differently with each other. This results in group harmony, which is crucial for problem-solving. In addition, each person brings a certain level of knowledge and experience and, through a possible breadth of ideas and perspectives, influences both the overall creative performance of the team and the individual performance of the other members through a possible exchange of information (Ocker 2005). The interrelationships amidst the combs can be perceived as a consolidation of numerous linkages between individual factors from different clusters.

The numbers shown behind the name of every category and on the connections refer to the references that are depicted. These are explained in Table 2. Sources for the categories (clusters) and their interrelationship. Numbers that are included in the combs, but not directly associated with the name of the category show a connection between the two categories that it borders on.

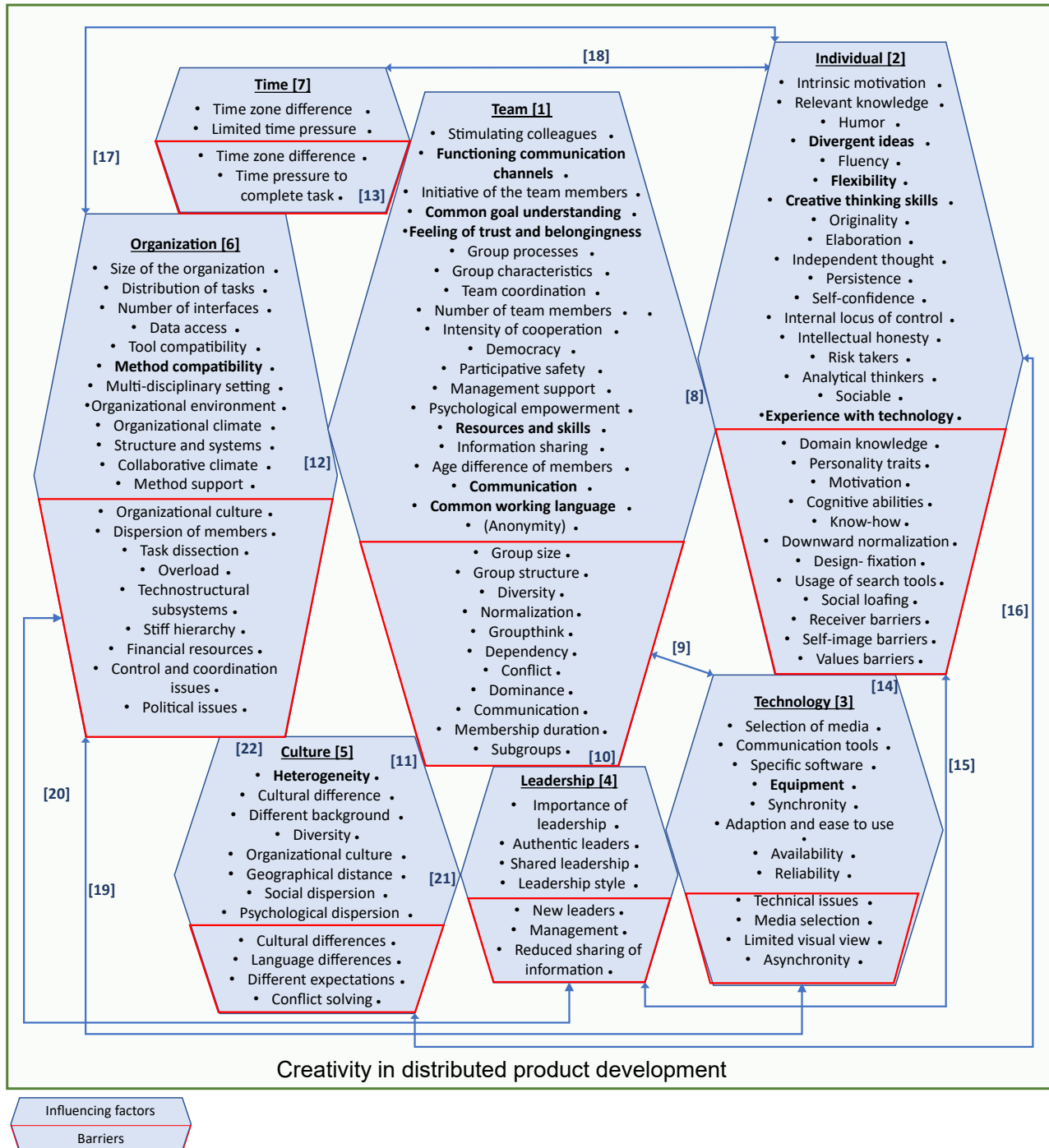


Figure 1. Success Factors and Barriers to Creativity and Interconnections between Categories based on (Bastian et al., 2023)

Table 2. Sources for the categories (clusters) and their interrelationship

Source	number	cluster	Type of interconnection	
(Hubounig S., Ingrassia S. & Krause D.E., 2013)	[1]	Team	influences	Creativity in distributed product development
(Saad and Agogu�, 2023)	[2]	Individual	influences	Creativity in distributed product development
(Saad and Agogu�, 2023) & (Brucks M. S., Levav J., 2022)	[3]	Technology	influences	Creativity in distributed product development
(Saad and Agogu�, 2023)	[4]	Leadership	influences	Creativity in distributed product development
(Seus F., 2020)	[5]	Culture	influences	Creativity in distributed product development
(Ocker ,2005) & (Brucks M. S., Levav J., 2022)	[6]	Organization	influences	Creativity in distributed product development
(Seus F., 2020) & (Ocker, 2005)	[7]	Time	influences	Creativity in distributed product development
Source	number	cluster	Type of connection	cluster
(Ocker, 2005)	[8]	Team	Influence each other	Individual
(Verburg R.M., Bosch-Sijtsema P., Vartiainen M., 2013)	[9]	Team	Influence each other	Technology
(Saad E.A., Agogu� M., 2023)	[10]	Team	Influence each other	Leadership
(Martins and Shalley, 2011)	[11]	Team	Influence each other	Culture
(Andriopoulos, 2001)	[12]	Team	Influence each other	Organization
(Wessel F., 2012) & (Monalisa M. et. al., 2007) & (Ocker, 2005)	[13]	Team	Influence each other	Time
(Verburg R.M., Bosch-Sijtsema P., Vartiainen M., 2013)	[14]	Individual	Influence each other	Technology
(Saad E.A., Agogu� M., 2023)	[15]	Individual	Influence each other	Leadership
(Bergstr�m and T�rlind, 2007)	[16]	Individual	Influence each other	Culture
(Andriopoulos, 2001)	[17]	Individual	Influence each other	Organization
(Wessel F., 2012) & (Monalisa M. et. al., 2007) & (Ocker, 2005)	[18]	Individual	Influence each other	Time
(Saad and Agogu�, 2023)	[19]	Technology	Influence each other	Organization
(Verburg R.M., Bosch-Sijtsema P., Vartiainen M., 2013) & (Saad E.A., Agogu� M., 2023)	[20]	Leadership	Influence each other	Organization
(Wessely F., 2012)	[21]	Leadership	Influence each other	Culture
(Andriopoulos, 2001) & (Hubounig S., Ingrassia S. & Krause D.E.,2013)	[22]	Organization	Influence each other	Culture

The second level of the impact model, which is shown in *Figure 3: Interconnections between individual barriers*, focuses on the interconnections between individual barriers. A total of 15 interconnections have been identified whereby nine of them correlate to individual and team barriers. In contrast to *Figure 2*, the success factors are not depicted in *Figure 3* as they do not provide additional information and are already shown in the previous figure. *Table 3. Sources for the Interconnections between the Barriers* provides the sources for every named connection that is shown in *Figure 3*.

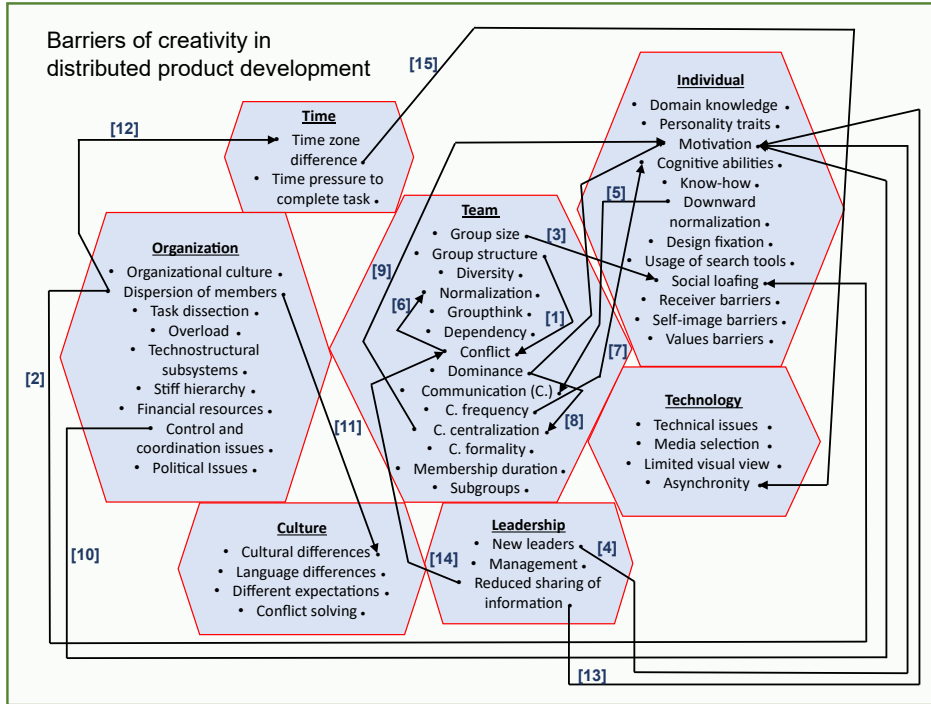


Figure 2. Interconnections between individual barriers

Table 3. Sources for the Interconnections between the Barriers

Source	number	Barrier	Type of interconnection	Barrier
(Hubounig S., Ingrassia S. & Krause D.E., 2013)	[1]	Group structure	Has an influence on	Conflicts
(Saad and Agogu�, 2023)	[2]	Dispersion of members	Has an influence on	Social loafing
(Saad and Agogu�, 2023)	[3]	Group size	Has an influence on	Social loafing
(Saad and Agogu�, 2023)	[4]	New leaders	Has an influence on	Motivation
(Ocker, 2005)	[5]	Downward normalization	Has an influence on	Communication
(Ocker, 2005)	[6]	Conflicts	Has an influence on	Normalization
(Leenders R. Th.A.J., van Engelen Jo M.L., Kratzer J., 2003)	[7]	Communication frequency	Has an influence on	Cognitive abilities
(Leenders R. Th.A.J., van Engelen Jo M.L., Kratzer J., 2003)	[8]	Dominance	Has an influence on	Centralization of communication
(Leenders R. Th.A.J., van Engelen Jo M.L., Kratzer J., 2003)	[9]	Centralization of communication	Has an influence on	Motivation
(Berhausen N.P., Thrane S., 2018)	[10]	Control and coordination issues	Has an influence on	Motivation
(Verburg R.M., Bosch-Sijtsema P., Vartiainen M., 2013)	[11]	Dispersion of members	Has an influence on	Cultural differences
(Verburg R.M., Bosch-Sijtsema P., Vartiainen M., 2013)	[12]	Dispersion of members	Has an influence on	Time zone
(Brinkmann A., Dreilich G., Stadler C., 2022)	[13]	Reduced sharing of information	Has an influence on	Motivation
(Brinkmann A., Dreilich G., Stadler C., 2022)	[14]	Reduced sharing of information	Has an influence on	Conflicts
(Wessel F., 2012)	[15]	Time zone	Has an influence on	Asynchrony

5. Conclusion and Outlook

It has been shown through the results of the systematic literature review that a variety of barriers to creativity in distributed product development exists. These barriers have been collected and explained in chapter 4. *Barriers to creativity in Distributed Product Development* to answer the first research question. The individual barriers are described and their inhibiting effect on creativity is explained. The majority of barriers stem from the categories of *Individual, Team, and Organization*. Upon closer examination of the individual factors and descriptions, it becomes evident that the categories of *Technology, Culture, Leadership, and Time* also possess essential barriers, which are necessary for a comprehensive understanding, differentiation and gathering of inhibitors of creativity.

The interconnections between the barriers as well as the interconnections between clusters are explained and shown in detail in Chapter 4. *Barriers to creativity in Distributed Product Development* answering research questions two and three. The barriers were integrated into the impact model by Bastian et al. (2023) resulting in a graphical representation of the entirety of success factors and barriers to creativity and the high number of interconnections.

Since the number of virtual teams keeps on rising (Dekoninck and Brenninkmeijer 2022), the need for further research on how to nurture creativity is clear. Clear is also, that the barriers found cannot claim completeness, since barriers that are not yet described in literature might be found when collecting data in the field. An example from personal experience is an additional barrier concerning language barriers. Language barriers can not only be due to different languages themselves but also due to domain-specific language. Furthermore, some barriers consist of different aspects and might need to be broken down into multiple barriers after further research. Conducting detailed studies in the field is the next step for detailing and developing the impact model further in an iterative process. However, the impact model serves as a foundation for future research in the realm of fostering creativity. Especially the category culture seems to be an interesting starting point for further studies and for developing additional support for distributed product development teams since more and more teams are multicultural and distributed. Finding ways to overcome the barriers, especially within this category and to enhance the success factors are also next steps within a follow-up study.

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Biographies

Annika Bastian graduated with a bachelor's degree in International Management in 2021 and received a master's degree one year later in 2022 from the Hochschule Karlsruhe - University of Applied Sciences. She now is a doctoral researcher in the research group Design Methods and Design Management at the Institute of Product Engineering of the Karlsruhe Institute of Technology, where she started in 2022. Her research interests include creativity in product development, cultural influences on creativity and managing distributed or virtual teams in product development.

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Christoph Kempf studied from September 2012 until September 2019 mechanical engineering at Karlsruhe Institute of Technology (KIT). This education was supplemented by one year of studies abroad in the context of a dual degree program with KAIST – Korea Advanced Institute of Science and Technology. In 2019 Christoph Kempf graduated from both universities and received his Master of Science degrees. Starting in September 2019 Christoph Kempf now works as a doctoral researcher at IPEK – Institute of Product Engineering at Karlsruhe Institute of Technology (KIT). His research interests are in agile product engineering, and knowledge management and design reuse in product engineering.

Albert Albers has been full professor for product development and head of IPEK - Institute of Product Engineering at the Karlsruhe Institute of Technology (KIT) since 1996. He received his doctorate in 1987 under Prof. Palandan of the University of Hannover. Before his appointment to Karlsruhe, Prof. Albers worked for LuK GmbH & Co. OHG, most recently as head of development and deputy member of the management board. He is a founding and former board member of the scientific society for product development WiGeP, a member of the German Academy of Science and Engineering (acatech) and a member of the Advisory Board of the Design Society. Since 2008, he has been President of the Allgemeiner Fakultätentag (AFT e. V.). In addition, Prof. Albers engages in the VDI and serves on the advisory boards of several companies. In 2016, he and the IPEK team were awarded the Honorary Award of the Schaeffler FAG Foundation for excellent achievements and competencies in science, research and teaching in the technical-scientific field.