Diversity and Innovativeness in New Product Development Teams

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Addressing Dynamic Aspects With Simulation

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Abstract

Various empirical studies investigate the correlation between diversity and innovativeness in New Product Development teams (NPD teams). However, those studies show various and contradicting results. Diversity can be a resource that helps to strengthen the innovativeness of a NPD team. On the other hand, diversity can act as a risk that leads to diminished team cohesiveness and thus obstructs innovativeness. Numerous other factors influence the innovativeness of a heterogeneous NPD team.

In this paper, we will discuss if and how simulation as a complementary method to empirical studies can help to shed light on the complex and contradicting effects of diversity on innovativeness of NPD teams. Simulation models can help to analyze the diversity problem and its dynamic behavior as well as to allow insight into the basic underlying structures. Thus, simulation can show, where further empirical data is needed, can help in developing and testing new theory, and can support organizations in gaining a better understanding of heterogeneous NPD teams and implement practical solutions. We will show a highly aggregated and simplified System Dynamics model to illustrate the potential simulation has as a complementary method in the area of diversity research.

Introduction

To strengthen their innovativeness and thus competiveness, organizations often assemble new product development teams (NPD teams) composed of inter-disciplinary and cross-functional team members. The combined knowledge and skills of team members from different functional backgrounds and thus team members with a variety of individual thought worlds, views, and experiences, is thought to increase a team's creativity and innovativeness (Paulus 2000; Lovelace et al. 2001; Gebert et al. 2006).

Heterogeneous team members have a greater range of perspectives and thought worlds, which, through considering a wider variety of potential solutions, can lead to higher innovativeness than a homogeneous team can achieve. Therefore, higher diversity within NPD teams can lead to higher innovativeness (Milliken and Martins 1996; Amabile 1998; Gebert et al. 2006).

On the other hand, diversity of NPD team members can be a risk for innovativeness. Different perspectives and thought worlds of team members from different functional areas can cause barriers for communication within a team and diminish team cohesiveness. Thus, diversity of team members can hinder team innovativeness (Ancona and Caldwell 1992; Milliken and Martins 1996; Lovelace et al. 2001; Gebert et al. 2006).

Empirical studies show results, which are seemingly contradicting in the effects of diversity in NPD teams on team innovativeness. Thus, further investigation is needed in the area of diversity and innovativeness in NPD teams. We propose to use simulation as a complementary research method to empirical studies. In this paper we will show, how simulation can help to understand the complex interactions and relationships of diversity and innovativeness.

First, we introduce the basic concepts of diversity of functional background in NPD teams and the positive and negative effects it can have on the team's innovativeness. Next, we show when and how simulation can help to develop and expand theory and to get a better understanding of the underlying structures of diversity in teams. We then propose to use simulation as a complementary method to approach the diversity issue and its dynamic aspects. After choosing a simulation approach, we show an exemplary, highly aggregated and simplified System Dynamics model and its simulation results to illustrate how a simulation model can integrate the various empirical findings and help to understand the basic structures of the diversity problem.

Diversity and Diversity Effects

Diversity in teams describes the heterogeneity or variety of the individuals in teams concerning a number of different dimensions (Tilebein and Stolarski 2008). In NPD teams, highly job related diversity dimensions include team and organizational tenure, educational background, and functional background of team members (Pelled 1996). Functional diversity or cross-functionality refers to the functional areas of an organization, from which the team members originate. Higher functional diversity is thought to lead to better decision-making regarding team creativity (Gebert et al. 2006; Akgün et al. 2008) and has a high impact on the team's creativity process (Milliken and Martins 1996; Pelled 1996; Gebert et al. 2006). Empirical data shows controversial results concerning the effects of diversity on innovativeness mentioned in the previous chapters (Milliken and Martins 1996; Kreidler and Tilebein 2011). For a detailed literature review on diversity in NPD teams, see Kreidler and Tilebein 2011.

According to empirical studies, numerous factors moderate and mediate the correlation between diversity and innovativeness, exemplary naming team management, attitude of team members toward diversity, and motivation of team members (Granovetter 1973; Ancona and Caldwell 1992; Gebert et al. 2006). In the following, we do not take into account any other influencing mediating or moderating factors. In addition, we only investigate into the effects of cross-functionality in NPD teams, since this diversity dimension is often regarded in empirical studies (Kreidler and Tilebein 2011).

Different empirical studies propose contradicting effects of functional diversity on innovativeness in NPD teams. Overall, two different trends can be distinguished: While some studies see diversity as a resource that should be exploited, other studies suggest that diversity can act as a risk that should be avoided (Milliken and Martins 1996; Van der Vegt and Bunderson 2005; Gebert et al. 2006; Cabrales et al. 2008).

On the one hand, wider educational and functional backgrounds of heterogeneous team members lead to a wider variety of mental models and thus a greater overall knowledge than in a homogenous team. This can lead to an increased range of ideas, which strengthen the innovativeness of a team (Milliken and Martins 1996; Amabile 1998; Van der Vegt and Bunderson 2005). Through their diverse backgrounds concerning expertise, experience, and

thought worlds, team members can recombine ideas to produce new and innovative solutions (Amabile 1998). Thus, considering the positive effects of diversity, a heterogeneous team can work out ideas, solutions, and products that are greater in number and more creative and innovative than a homogenous team can achieve.

On the other hand, through different grounds of language, higher barriers for communication can arise. Social categorization and a tendency to form sub-groups can complicate working together and finding a common solution (Gebert et al. 2006; Gibson and Gibbs 2006; Cabrales et al. 2008). The possibility that conflicts arise is higher than in homogenous team, especially conflicts on value and relationship level, which lead to a decreased team cohesiveness (Jehn and Mannix 2001; Jehn and Bezrukova 2004; Gebert et al. 2006). Diversity can obstruct synergistic communication, which is essential for innovativeness. We use synergistic communication to describe the kind of communication, which is needed to take into consideration and recombine ideas to new and useful solutions (Gebert et al. 2006). Without synergistic communication, a team cannot be innovative. Hence, instead of leading to a higher innovativeness, high diversity can diminish a team's innovativeness.

Making the correlations even more complex is the fact, that some of these factors undergo dynamic changes as team interactions progresses over time. Through working together, the team members' mental models assimilate and the positive and negative effects of diversity lessen over time (Perry-Smith and Shalley 2003). Factors like entry and exit of team members, group socialization, and changing frameworks add to the dynamic effects of teamwork.

As most empirical studies in this field are cross-sectional studies, they typically cannot capture these dynamic aspects of diversity in teams and cannot help to understand, how the effects change over time.

Simulation as a Complementary Method

Existing empirical studies cannot capture the whole picture of the contradicting effects of diversity and innovation and cannot shed light on the dynamic effects of creativity. Simulation, however, can integrate the different finding from empirical studies and take into account the dynamic changes. Thus, we propose to consider simulation as a complementary approach to gain insight into the complex interactions of the matter and to lead to a better understanding of the

problem. Simulation can thus help to develop and expand theory in the research area and give directions for future empirical research.

Davis et al. 2007 propose to use simulation in field of strategy and organizations for problems, which cannot be resolved by empirical studies, which have dynamic effects, feedback loops, and non-linear structures and address a basic tension or conflict (Davis et al. 2007; Stolarski and Tilebein 2009). Problems, with some empirical backing, that shows insight into the underlying structures, but does not detail the exact correlations and relationships between different influencing factors, can be analyzed with a simulation model. Some empirical data exists, which helps to gain enough theoretical understanding of the problem to build a simulation model. On the other hand, such problems with limited empirical backing offer the chance to accept new insight, and theory development through simulation is possible (Davis et al. 2007).

Empirical studies addressing diversity and innovativeness in NPD teams provide some overview of the effects diversity, but fail to reveal all interactions as well as dynamic changes. Empirical data provide a solid basis, on which a simulation model can be build. Diversity in NPD teams has contradicting effects on the teams' innovativeness, which we have discussed at length in the previous chapters.

However, empirical studies cannot analyze the dynamic aspects of diversity. The assimilation of mental models, for example, causes the positive and negative effects of diversity to change over the time a team works together. Additionally, empirical data shows some evidence that non-linear behavior exists. Exemplary naming Leenders et al. 2003, who show a U-shaped relationship between communication and creative performance in heterogeneous NPD teams. Dynamic aspects arise through the assimilation of mental models over the time of teamwork, causing the initial effects of diversity change.

The mentioned above non-linear behaviors, dynamic effects, and feedback loops make it difficult to investigate the problem with cross-sectional studies. Thus, the question, how diversity affects the innovativeness of NPD teams qualifies to be analyzed with a simulation model.

Davis et al. 2007 provide a guideline for the creation and usage of simulation models in the field of strategy and organizations. This roadmap leads from a research question to a simulation model and the contribution it can bring, in a research area in which simulation does not play a major role

yet (Davis et al. 2007; Stolarski and Tilebein 2009). The first step is to determine a research question and to identify and analyze relevant research concerning the research question. Following next is the choice of a simulation approach, which fits the research question and the creation of a simulation model. The next steps are the verification and validation of the model as well as experimentation to develop further theory.

In this paper, we want to take a first step in the direction of using simulation for investigating into the complex interactions of diversity and innovativeness in NPD teams. In the following, we will show an exemplary, highly aggregated and simplified, System Dynamics model to illustrate the contribution simulation can make to the field of diversity studies.

Choosing a Simulation Approach

In this chapter we show, why we use a System Dynamics model as a first approach for the diversity problem.

Principally, Agent Based Modeling offers a suitable simulation approach for the problem. The individual team members can be modeled as agents to interact with each other by a set of rules (Schieritz and Milling 2003; Stolarski and Tilebein 2009).

While Agent Based Modeling describes the team members on a micro level, System Dynamics can help to model and analyze the underlying structures of teams on a macro level. System Dynamics can help to model and simulate the structures of the diversity effects on innovativeness on team level (Schieritz and Milling 2003; Stolarski and Tilebein 2009). Thus, we use System Dynamics as a first approach to a highly aggregated model, to show the advantages, simulation has to offer to the field of diversity studies in NPD teams.

In the following, we show and discuss a System Dynamics model, which integrates the two contradicting trends, diversity as a resource and diversity as a risk for innovativeness, and the above-mentioned feedback effects through the assimilation of team members' mental models.

Simulation Model Diversity and Innovativeness

Figure 1 shows a highly aggregated System Dynamics model, which captures the basic effects and dynamics of cross-functional diversity in NPD teams shown in empirical data and discussed

in the previous chapters. Details and other mediating and moderating factors or effects on individual team members are not considered in the model.

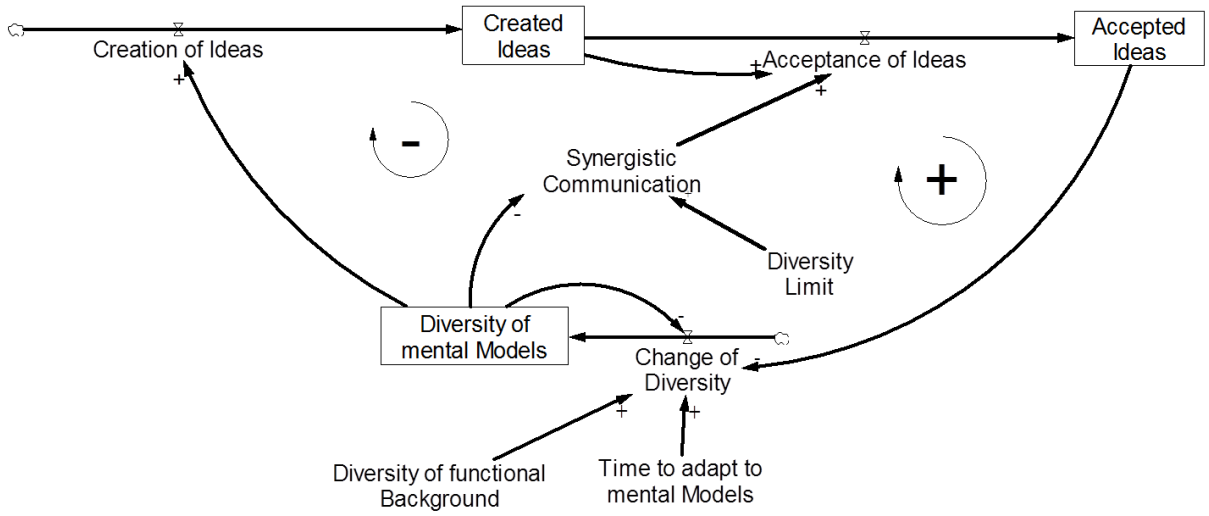

Figure 1: System Dynamics Model

Since it is difficult to measure the innovativeness of a team directly (Leenders et al. 2007), many empirical studies focus on the number and diversity of created ideas, solutions, or products within the team (Paulus 2000; Lovelace et al. 2001; Cabrales et al. 2008; Stahl et al. 2010; Kreidler and Tilebein 2011). Through their wider knowledge and experience backgrounds, heterogeneous team members can generate more potentially useful ideas (Milliken and Martins 1996; Gebert et al. 2006). Thus, the main stock and flow process in the model represents a simplified idea generating process of NPD teams as the creation of (potentially useful) new ideas. The first step is the creation of ideas, which leads to a pool of *Created Ideas*. Those ideas then need to be accepted within the team to be recombined to useful solutions and outcomes (*Accepted Ideas*).

In the current model, all created ideas are accepted within the team eventually. A discarding of ideas that are not accepted within a certain time would not change the qualitative results of the model. The model does not regard how many of the accepted ideas are actually implemented nor the quality and usefulness of the ideas.

The stock *Created Ideas* is defined by the inflow of *Creation of Ideas* and the outflow of *Acceptance of Ideas*, with the initial value zero. Thus:

$$Created\ Ideas = \int (Creation\ of\ Ideas - Acceptance\ of\ Ideas).$$

The *Acceptance of Ideas* depends on the number of *Created Ideas* and the *Synergistic Communication*. The higher the number of available created ideas, the higher the number of accepted ideas. In the process of accepting ideas, the synergistic communication represents the percentage of ideas that are accepted.

The initial diversity of team members is represented by the stock *Diversity of mental Models*. This variable has to controversial effects in the model: Firstly, a NPD team with higher diversity of mental models can create more ideas, thus diversity is a resource for innovativeness within the team. Through a greater pool of knowledge, a team with high diversity can generate ideas that are more diverse (Milliken and Martins 1996; Amabile 1998; Van der Vegt and Bunderson 2005). Thus, the variable *Creation of Ideas* in the model is defined as:

$$Creation\ of\ Ideas = Diversity\ of\ mental\ Models$$

Secondly, the higher the diversity of mental models, the lower the synergistic communication (based on Gebert 2004; Gebert et al. 2006). Synergistic communication however, is essential to ensure an outcome oriented discussion about the various created ideas within a team and thus essential to accept those ideas and consider them as suitable alternatives. The higher the diversity of mental models, the lower the synergistic communication. Therefore, we define *Synergistic Communication* in the model as:

$$Synergistic\ Communication = max(1 - Diversity\ of\ mental\ Models/DL\ , 0).$$

DL (*Diversity Limit*) represents the amount of diversity from which synergistic communication is not possible anymore. *Synergistic Communication* has a value between zero (low) and one (high) and represents the percentage of created ideas that can be accepted by the team.

Hence the *Acceptance of Ideas* in the model is:

$$Acceptance\ of\ Ideas = Syneristic\ Communication \cdot Created\ Ideas$$

The term *Diversity of mental Models* is represented as a stock, with the inflow *Change of Diversity* and the initial value being *Diversity of functional Background*. The change of diversity is influenced by the initial diversity of functional background, the diversity of mental models, and

the *Time to adapt to mental Models* (*AT*), which can be adjusted while simulating. Through working together, a team's diversity of mental models decreases. In the model, this is represented by the influence of *Accepted Ideas* on the change rate. The more ideas a team has accepted in the past, the more the team members' mental models assimilate. The factor *Time to adapt to mental Models* (*AT*) defines how fast this process occurs.

Thus, the *Change of Diversity* is defined as:

$$Change\ of\ Diversity = \left(\frac{Diversity\ of\ functional\ Background}{\max\left(Accepted\ Ideas, 1\right)} - Diversity\ of\ mental\ Models/AT\right)$$

The change of diversity of mental models influences the idea generating process of team: The amount of newly created ideas within a team decreases, while synergistic communication is enhanced. The dynamic effects in an initially heterogeneous team assimilate to the effects of an initially homogeneous team. The barriers for working together lessen while the potential benefits of diversity decline as well.

Simulation Results

In this chapter, we will show and discuss the simulation results of the highly aggregated, very simplified simulation model shown in the previous chapter. For a first step qualitative results are shown, which suffice to show insight into basic underlying processes and structures.

For the simulation, we define *Diversity of functional Background* within a range of 1 and 100 with 100 being the *Diversity Limit*, the point of diversity from which synergistic communication within a team is not possible anymore and from which a team cannot work together at all. For the simulation, we compare three different levels of diversity: high (99), medium (50), and low (10), representing a highly heterogeneous, a moderately diverse, and a homogeneous team composition.

In the following, we will show and discuss the simulation results for these three different levels of diversity. We do not define the timeframe within the simulation in detail, with the initial time being the starting point of a team working together.

The simulation results for the *Diversity of mental Models* are consistent with empirical data: The higher the initial diversity of functional background, the higher the diversity of mental models (Milliken and Martins 1996). Figure 2 shows this at the initial time. Through the simulation time, the mental models assimilate to each other, which is consistent with empirical data as well (Granovetter 1973; Perry-Smith and Shalley 2003).

The *Diversity of mental Models* converges to zero, regardless of the initial value. The model does not take into consideration, whether the mental models within a highly diverse team assimilate completely or whether there will always be some level of diversity left, no matter how long a heterogeneous team works together. The lower the initial diversity of mental models, the faster they assimilate.

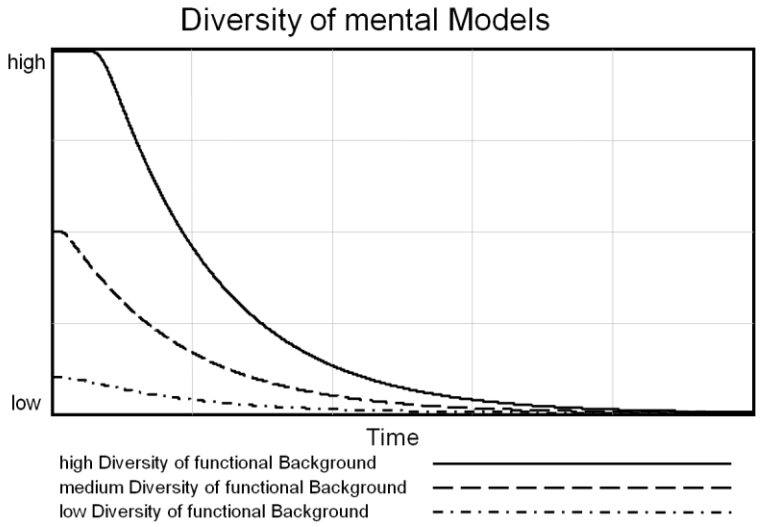

Figure 2: Simulation results for *Diversity of mental Models*

As mentioned above, the diversity of mental models has two effects. Firstly, the higher the diversity, the more ideas a team can create. Thus, the simulation results of the *Creation of Ideas* are exactly like the results shown in figure 2.

The *Created Ideas* are the integral of the *Creation of Ideas* minus the *Acceptance of Ideas* and are shown in Figure 3. The initial value is zero, since there are no ideas at the time team members start to work together. A heterogeneous team can create significantly more ideas than a homogeneous team. However, after some time the amount of newly created ideas decreases through the assimilation of team members' mental models. This effect happens in heterogeneous

and homogeneous teams alike, although the more diverse a team the longer it can create new ideas.

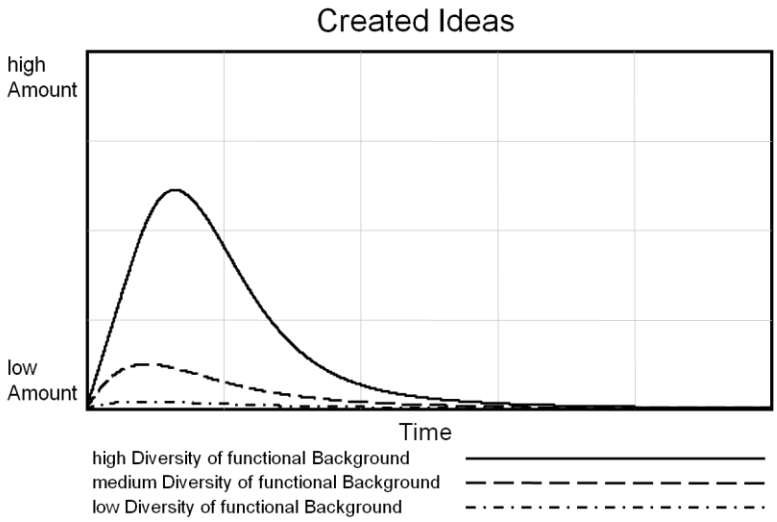

Figure 3: Simulation results for *Created Ideas*

The second effect the assimilation of mental models within a team has is on synergistic communication. Figure 4 shows the simulation results for *Synergistic Communication*, which are in accordance with empirical data (Gebert 2004; Gebert et al. 2006): First, the synergistic communication of a homogeneous team is higher than that of a heterogeneous team. Through the assimilation of mental models while working together, the synergistic communication increases in teams regardless of initial diversity. However, in homogeneous teams this effect takes less time than in heterogeneous teams.

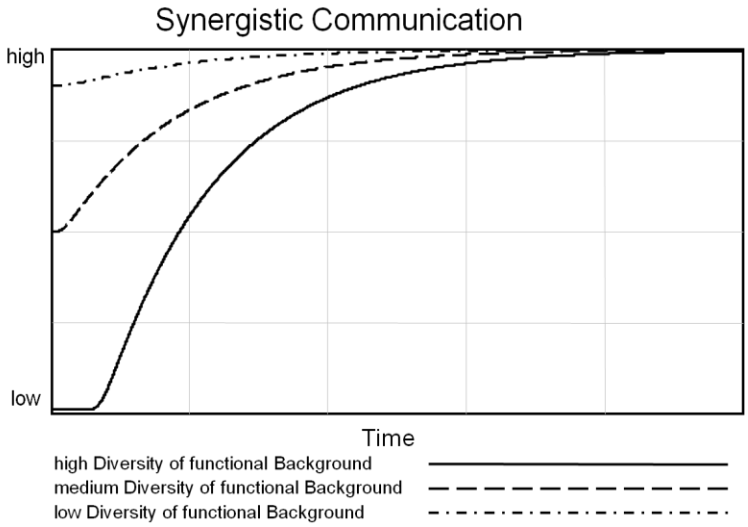

Figure 4: Simulation results for *Synergistic Communication*

Figure 5 shows the simulation results of *Acceptance of Ideas*. The results show, that while a homogeneous team can accept all of its created ideas, the amount of ideas is nominal compared to the amount of ideas in more diverse teams.

A team with medium diversity of functional background has a considerable higher amount of created ideas, while also accepting most of those ideas. A highly heterogeneous team has the highest amount of created ideas, but also the highest barriers for accepting them. At the beginning the synergistic communication is so low that no or only very few ideas can be accepted at all. Team members need a significantly longer time of working together before starting to communicate in a way that allows them to accept the created ideas. Those simulation results are in accordance with empirical data as well (Perry-Smith and Shalley 2003; Gebert et al. 2006).

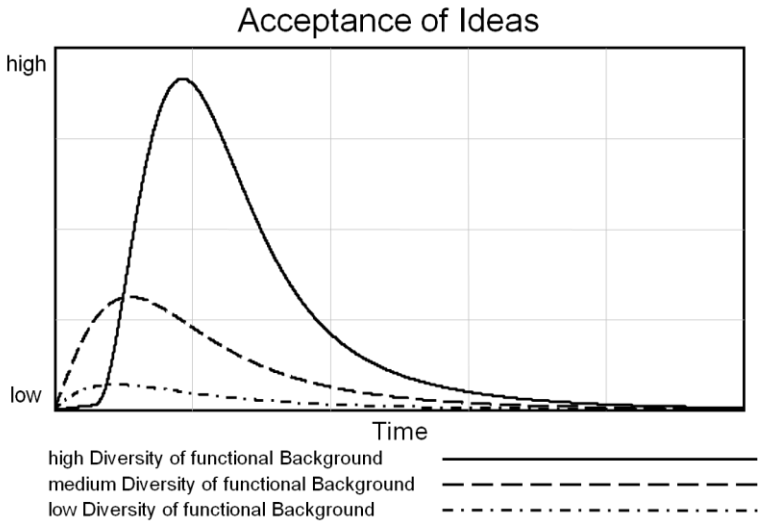

Figure 5: Simulation results for *Acceptance of Ideas*

The same behavior can be seen in the simulation results for the *Accepted Ideas*, which are shown in Figure 6. At first, a team with medium diversity accepts more ideas than a team with high diversity. However, after the initial communication problems, a team with high diversity has the potential to accept considerately more ideas.

The simulation results show that at the beginning of working together, a heterogeneous team accepts only few ideas, while a homogeneous team produces ideas fast. In the end however, the creative potential of a homogeneous team diminishes very quickly while, after overcoming the initial problems, a heterogeneous team has the potential to work creative over a longer span of time.

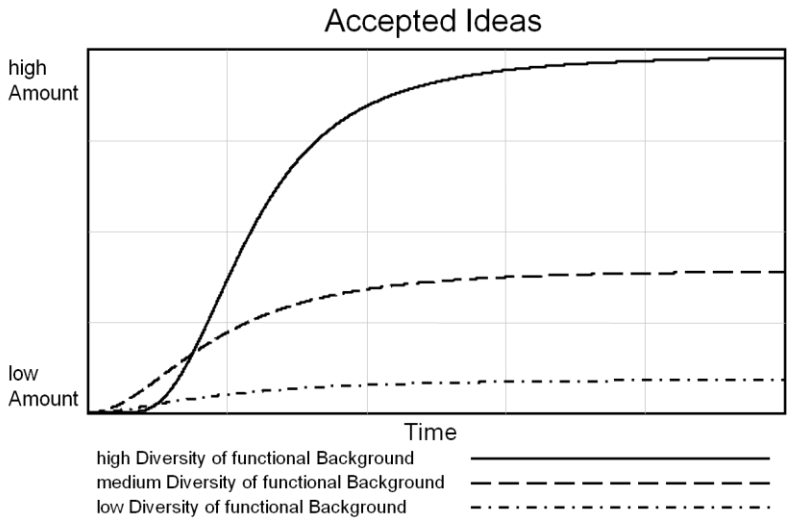

Figure 6: Simulation results for *Accepted Ideas*

This effect is caused by the reinforcing loop in the simulation model (+). More accepted ideas lead to a lower diversity of mental models, which enhances synergistic communication and thus a better acceptance of ideas.

Over a longer time, a different effect takes place: The creation of ideas lessens through the assimilation of mental models. Thus, while working together, less new ideas are created in homogeneous and heterogeneous teams alike. The higher the initial diversity of functional background, the longer a team can produce ideas. Empirical data backs up this effect (Perry-Smith and Shalley 2003).

In the simulation model, this is caused by the second, balancing, feedback loop (-). Through working together, team members produce fewer ideas. Therefore, fewer ideas can be accepted over time, even though synergistic communication increases. Thus, the amount of accepted ideas in a team is limited over time.

The two feedback loops caused by diversity of mental models within a team, less created ideas and higher synergistic communication, balance each other over time.

Practical Implications

The results of the simulation model can to draw conclusions for first practical implications.

Higher functional diversity in NPD teams leads to higher creative potential as well as to higher barriers for accessing the potential. Jobs, which need results fast, or routine tasks call for teams that are more homogeneous.

With the knowledge, that teams with high functional diversity have a potentially higher innovativeness but need more time to overcome the initially high communication barriers, organizations are able to take measures to exploit the potential of heterogeneous NPD teams fully. Especially tasks and problems, which need a considerable number of new ideas, solutions, or problems, like the early stages of innovation processes, can benefit from teams with high diversity of functional background. The knowledge, that such teams have high barriers for communication, especially at the beginning, can help organizations to counteract those problems with methods like communication workshops, or the use of moderators and mediators in heterogeneous teams.

Summary and Outlook

In this paper, we have discussed a System Dynamics model, which represents a simplified idea generating process of an NPD team to show, how simulation can be used as a complementary method for empirical studies in the field of diversity research. The simulation model includes seemingly contrary effects of diversity of functional background in NPD teams on team innovativeness as well as the dynamic change of those effects. The model integrates the two main trends of heterogeneity in NPD teams, diversity as a resource and diversity as a risk for innovativeness and their dynamic behavior. The simulation results of the model illustrate how those two effects interact over time.

The model shows, that simulation can be used as an alternative, complementary approach to investigate into the complex dynamics of diversity in NPD teams and their basic causalities. Simulation as a complementary method can help to integrate the seemingly controversial empirical results of diversity in NPD teams and to understand and illustrate the dynamic effects. Thus, a better understanding and insight of the effects of diversity in NPD teams on teams' innovativeness can be gained.

Numerous other factors influence teamwork, which we did not take into consideration in our model. The next step will be to analyze the effects of those factors and their dynamic behavior to

integrate the findings into a more sophisticated model. For this, we will need specific and definite data from empirical studies, which quantifies diversity and innovativeness in NPD teams.

Such a simulation model can than demonstrate, where further empirical studies are needed and help to develop new theories. Simulation results from different scenarios can help organization to better understand the composition and working processes of heterogeneous NPD teams and discuss practical implications. For example, different stages of the innovation process or different tasks call for different strategies. Homogeneous and heterogeneous teams need to be assigned to suitable tasks, to develop their full potential and contribute to an organization's success.

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