Face to face with ambiguity and diversity: dynamics of interdisciplinary team work in different phases of explorative new product development projects

Satu Rekonen[1]

[1]*Aalto University Design Factory*
satu.rekonen@aalto.fi

Abstract
This study investigates the dynamics of interdisciplinary teamwork in explorative New Product Development projects and the challenges this demanding context sets for the individuals working in the team. The study adopted a longitudinal, qualitative research approach comparing the front-end and later development phases of two NPD projects. Altogether 13 semi-structured interviews were conducted. The results suggest that individuals working in interdisciplinary NPD project teams need to deal with high level of ambiguity and uncertainty related to the project itself, the diverse ways of working and thinking due to the different educational backgrounds, but also to one's own role in the project. Role ambiguity was noted to have far-reaching effects, including how much freedom and autonomy team members were willing to allow for each other. The findings suggest putting effort early on in the project on purposefully establishing ways of working that support open communication and subsequently help diminish ambiguity.

Keywords: Interdisciplinary teamwork, new product development, front-end phase, ambiguity

1   Introduction

The value of cross-functional, interdisciplinary teams in explorative projects, such as new product development (NPD) is undeniable. Cross-functional and interdisciplinary teams are suggested to be well adaptable to dynamic and changing business needs [1] and it is commonly agreed that diversity in expertise, skills and knowledge is favourable to group innovativeness [2,3,4]. Through the variety in perspectives, opinions and approaches wider range of solutions to a given problem can be achieved [2] and it has also been suggested that bringing together different backgrounds can lead to highly successful and disruptive innovations and creative outputs [5,6].

However, things are not so simple and diversity cannot be assumed to possess purely positive influences. As Kessler and Chakrabarti [7] have noted, team member diversity exposes a variety of viewpoints and allows to consider of a wider range of perspectives in the product design and process it does not, however, ensure this. For example, if not properly managed, differences in skills and knowledge may lead to significant interaction difficulties among team members [2]. Further, NPD teams are comprised of members from different functions and disciplines who need to integrate their deep expertise in multiple areas in order to develop innovative solutions [8]. Also, in many cases project teams, forming a temporary action-

oriented organizations within the parent organization [9], consist of members who are not familiar with each other, which sets more challenges for the project team already in the formative phase [2]. Furthermore, collaboration in cross-functional, interdisciplinary teams poses a challenge as each discipline has its own language, approach to learning, and beliefs about relative importance of performance attributes, among other issues [10]. It is commonly agreed that teamwork in cross-functional and interdisciplinary teams is particularly challenging [see e.g. 10,11] and the competing viewpoints that are essential in promoting creative new ideas and thorough decision making are also possible sparks to conflicts that waste the team's time and cause interpersonal challenges [8].

To come up with innovative solutions, NPD teams must be ready to face ambiguity and uncertainty, both key moderators of NPD team performance [12,13]. In the inherently explorative NPD projects, where neither the goal nor the means to reach the goal are known in the beginning [14] this information needs to be created through explorative experiments, aimed at learning and discovery. The learning-approach is about moving toward the best outcome that one is able to identify, and at the same time being prepared to repeatedly and fundamentally change both the outcome and the course of action as new information becomes available [15]. In other words, the team iterates and learns through experiments. In addition to experimentation, help seeking [16], and freedom to express one's point of views related to the project without the fear of negative judgement [17,18] is needed for the learning required to develop novel and innovative solutions. However, as Edmondson [19] has noted, all these behaviors involve interpersonal risks, such as, the risk of appearing incompetent or disagreeable, which make working in the interdisciplinary and explorative NPD projects even more demanding.

Further, when ambiguity and uncertainty are too high, team performance may start to suffer. According to Weick [20] for example frequent communication and respectful interaction are ways to support team work in stressful situations. However, in diverse teams, a number of interpersonal factors can suppress the progress of well functioning communication and these kind of courses of action can be difficult to bring about [20]. Further, previous research has emphasized paying careful attention to interpersonal conditions for teamwork in complex and dynamic tasks [17,11). This is due to the fact that team members working in explorative projects need to take action despite the discomfort of working together in an uncertain environment with a high risk of failure [11]. Previous research has found that teams that are able to move forward, despite the diverse viewpoints and discomfort of uncertainty and ambiguity, make use of creative tension [7] engaging in productive discussions rather than in disruptive conflict [21].

In addition, projects characterized with ambiguity and only partially defined goals call for collective creativity [22]. Creative work is often described to involve the solving of complex, ill-defined problems requiring the generation of novel, useful solutions [23] and to be an important part of new product development process. Several factors have been found to have influence on an individuals willingness to engage in creative endeavour, with establishing a supportive climate being one of the most critical ones when aiming at creative outputs and learning [17,11]. In particular, a climate of psychological safety, in which team members feel safe to express and voice their unique point of views, concerns, and mistakes, has been noted to be critical for innovative solutions and NPD work [e.g. see 17,24,11].

Furthermore, the diverse teams working in explorative NPD projects go through phases that are very different in their characteristics [25] e.g. the early "fuzzy" front-end phase and the later, more structured development phases [cf. Koen et al.,25]. These phases, inherently different in regards to e.g. state of an idea, nature of work and width and depth of the focus [25,26], require different approaches and mindsets from the innovation team, setting even more challenging conditions for successful teamwork. Working in an explorative project with a diverse team composition therefore poses a challenge to the team dynamics and teamwork in general. Even though many authors have recognized the challenging nature of teamwork in explorative projects, such as NPD projects, there is far too little knowledge regarding the challenges of interdisciplinary teamwork specifically in relation to the inherently differing phases of NPD projects.

To benefit the understanding on teamwork in demanding, explorative settings with high level of ambiguity and uncertainty, the present study thus proceeds to investigate the requirements and challenges set by the different phases of NPD projects for the diverse team and, more importantly, for the individuals working within the team. This viewpoint of the individual team member has been specifically underrepresented in the existing studies that have largely focused on team-level investigations. The reported study was conducted on an interdisciplinary University course with real-life company projects where the students face an explorative NPD challenge in unfamiliar fields and in teams whose members are previously not familiar with each other.

2   Methods

To investigate the challenges interdisciplinary teamwork in explorative NPD projects brings forth for the team and its individual members, this study adopted a longitudinal qualitative study approach following altogether six team members of two NPD teams throughout their NPD projects. Team members were interviewed twice during the project: at the beginning and in the middle of the project, resulting in 13 interviews (one interviewee interviewed only once as he quit the course for a job offer). These points in time were selected to correspond with the front-end and more directed development phases of the NPD project [cf. Koen et al., 25]. The interviews lasted between 31 and 63 minutes, averaging at 47 minutes. Data was collected from a graduate level product development course at [name of University anonymized], during the semester of 2010-2011. In the course, student teams are formed based on student applications, and each team is given a unique industry-provided real-world design brief. In addition to the design brief, the sponsor provides ca. 10 000 euro budget for the development work for the duration of the eight month course. The teams are required to produce a functional prototype as an end result to the course. The six to seven member teams consist of students from [name of University anonymized] in [country anonymized] as well as students from [name of University anonymized] in [country anonymized]. However, for the study only the students locaded in [country anonymized] were interviewed as the team members in different countries formed sub-teams that were operating as independent units. Straightforward content analysis was used to analyze data. The interview transcripts were screened for factors reported to affect the teamwork or individuals working in the team. Table 1 presents an overview of the interviewees.

Table 1 Interviewees' background

Team	Interviewee #	Background
A	1	designer
	2	engineer
	3	marketing / political science

B	4	information technology
	5	designer
	6	engineer
	7	business

3   Results

The main findings of the study regarding the challenges and dynamics of interdisciplinary teamwork faced by the the entire team or the individual team member of interdisciplinary NPD project fall under four categories: 1) role ambiguity, 2) accommodating to diversity, 3) balancing and iterating between abstract and concrete thinking, and 4) the strive for consensus. These categories are discussed in detail from the viewpoint of how these issues evolved between the front-end and later, more directed development phases of the NPD projects.

3.1   Role ambiguity

Several interviewees (1,2,3,4) expressed being hesitant about their role in the project and were feeling uncertain about whether they are fulfilling the roles they are expected to represent in the interdisciplinary team, even in the later phase of the project. For example, Interviewee 1 (2nd interview) described her worry on whether she is being creative enough as the designer of the team as follows:

"-- sometimes I've been worrying about my own input in that sense that am I now crazy and creative enough because sometimes I wonder if that's what they really expect from me since I am the designer. Actually, I have a pretty down-to-earth approach in everything I do. I don't know whether it makes sense or not but sometimes I am doubting whether I am fulfilling the expectations I am supposed to."

Especially in the front-end phase, many interviewees struggled with the ambiguity related to individual roles and responsibilities. Interviewees mentioned be unaware of what should be everyone's duty in the project and desperately to long for clearer roles so that they would know what is their area of responsibility and where to direct their efforts. In the later phase of the project, these problems were more absent. However, both interviewees 2 and 3 mentioned still in this phase to be hesitant about what would be the most useful role of his to take and noted not to be satisfied with his contribution to the project. The interviewees seemed to believe that they would have more to offer for the project if they only knew how to do it Since there was unclarity regarding what would be each one's role in the project, in the front-end phase, the teams ended up trying to do everything together as a team and not dividing the tasks, which according to the team members led to inefficiency and frustration. Yet, there were still doubts about whether more systematic approach to working would happen at the expense of exploring, as Interviewee 7 (1st interview) noted:

"That, kind of more systematic and organized approach towards work is lost at the moment. – But, on the other hand, the benefits that it would bring to us may not compensate for what we gain with thisapproach of going to different directions simultaneously."

However, majority of the interviewees (1,2,5,6) noted that in the later phase, the fact that the project was proceeding with increasing level of concreteness and the amount of work was increasing, had led to clearer division of work and as a consequence, more efficient working.

Finally, interviewees mentioned to be careful in strongly driving one's own points of view since they were not felt to be based sufficiently on facts but rather on one's gut feeling. This

was perceived to apply not just to oneself but to everyone else in the team as well. Further, in the front-end phase interviewees emphasized that in interdisciplinary team work, it is important that no one is emphasizing his or her own discipline too much and in that way dominating through his or her perceived expertise. However, in the later phases of the project, it was brought up that team members seemed to have had faded out their own discipline which yielded the notion that one should not forget his or her own educational background from which they should be looking at things.

3.2 Accommodating to diversity

In the front-end phase, the interviewees brought up challenges related to finding common ways of working as the methods and approaches the team members had been used to in their own discipline were perceived as being so different. Accommodating to diverse approaches and ways of working and interacting as well as establishing a common understanding was shifting the focus away from the actual task and project in the front-end phase. According to team members of Team A, significant amount of time was used to debating and trying to get an understand what the other was trying to say. The differences were most prominent regarding abstract thinking versus concrete doing. Interviewees representing different approaches in this sense mentioned it to be difficult to understand the other's point of view. Further, the fact that some team members had so different ways of looking at and approaching issues made it more challenging, yet also important to articulate one's point of view. The feeling of having to hold back one's natural way of working led to a significant amount of frustration.

"For me it was very frustrating that many times we were here for 14 hours and it felt that yes there is lot of discussion and finding out background information and reading all sorts of studies. But I had a feeling that it would be really nice to also start the concrete doing and prototyping." (Interviewee 2, 2nd interview)

As in the front-end phase the interviewees were still rather careful in their approaches and how to work in the team, they seemed not to have been able able to integrate the hands-on style with the more abstract approach in a beneficial manner. Due to the different approaches, interviewees indicated that in the front-end phase there was a need to control others pursuits more tightly and independent actions without informing the rest of the team was not appreciated, which was not the case anymore in the later phase. However, in the later phase, where the roles in the team had become clearer, interviewees had more trust on each other and allowed for autonomy more willingly.

"We were really strict on each other at the beginning because we had so different ways of working so we keeping each others on a lead so that no one would be soloing. Now again as we have given more space to each other's it all has worked much better. We have much more efficient division of work and better atmosphere because everyone has been able to do what they are good at."
        (Interviewee 1, 2nd interview)

In the front-end phase many of the interviewees recognized the need for paying attention to team's internal communication because of the diversity. Interviewees (1,2,3,4) described to have discussed with their team members about different ideas on how to ensure open communication within the team. For example, Interviewee 1 (1st interview) reflected that the issues brought up during the interview would be important to openly discuss also amongst the team. However, practices supporting the open communication among team members were not purposefully established within the teams. It seemed that as in the front-end phase there still existed such a big ambiguity regarding the project and the direction it should take, time was

not found for making practices supporting the open communication as deep-rooted ways of working within the teams.

3.3 Balancing and iterating between abstract and concrete thinking

Moving from the conceptual thinking of a higher abstraction level to the practical thinking of a lower level abstraction and concrete doing was a significant challenge highlighted by the interviewees. In the front-end phase the interviewees described it to be difficult to recognize how to utilize the data gathered for creating a better understanding on the project; what are the key elements to take into account and how to move towards concrete outcomes. Further, it was difficult for interviewees to identify smaller testable elements from a larger concept, which kept them from starting prototyping earlier on:

"After the [University anonymized] trip I was like the whole word is wide open to us and our project will be freaking great but then as our project is what it is so try to build a critical function prototype from that then…that's when my feeling towards the project started going down."
(Interviewee 3, 2nd interview)

It seemed that for some interviewees starting to prototype an idea meant the same as locking down the idea and not staying open to explore different options and as result, they were not so encouraging towards early prototyping. For example, the Interviewee 3 (1st interview) mentioned it to be important to ensure that the team is not making any rash decisions:

"Even though the nature of our project is very explorative and even though I like to be building stuff very much myself I think I have been the one that seems to be responsible for ensuring that we are not just thinking about the materials rather that what we are doing would really come from the users."

Even though concrete action and prototyping was mentioned to be one of the most inspiring aspects in the team work, maintaining that side along with the abstract thinking at the front-end phase was not easy.

3.4 Strive for consensus

Making decisions was a challenge brought up continuosly in the interviewees. There evidently was a strong need for reaching a consensus within the team in decision making as well as in ways of working, especially in the front-end phase. This led to situations where nothing could be locked and things were not proceeding as consensus was not reached. However, as Interviewee 2 (2nd interview) noted, it was perceived better to listen to everyone's point of view carefully and aim at common understanding eventhough it would be slower:

"It is dangerous if someone is taking a more dominating role in decision making -- it might give a bad feeling to others...I prefer to ponder something for hours rather than after one hour say: 'listen, this is how we'll proceed'. People have to have the right to thing things through, then it just is that the whole team will follow the pace of the slowest one."

Further, bringing up one's point of views more couragoeusly was called for as it seemed that it would spark more open sharing of different viewpoints:

"If our team would be a couple, our problem would be that we don't know how to fight [laughing] and what follows from that is that people are not sharing so sharp point of views or something to which it would be easier to take a stand on." (Interviewee 3, 2nd interview)

It was also recognized that the fact that the team was aiming at compromises and consensus might happen at the expense of passion towards the project. Interviewee 3 (2nd interview) mentioned that he would rather do something that few team members are very passionate about eventhough some would dislike it than to do something that is just okay for everyone.

4 Discussion and conclusions

The present study explored the challenges that interdisciplinary teamwork in explorative NPD projects sets for the team and for the individuals in the team in different phases of the project. Ttudy highlighted important elements to be taken into account in the different phases of NPD projects, highlighting the importance of adopting a longitudinal perspective in studying interdisciplinary teamwork in the context of innovation and NPD.

First of all, the study provides further support to previous studies highlighting the demanding nature of teamwork in interdisciplinary NPD projects [see e.g. 2,10,8]. Both of the teams in the study were facing challenges in *accommodating to diversity* regarding diverse approaches, ways of working, and point of views of the team members. These factors have been well recognized in earlier studies as well.

Second, this study supports the study of [28] emphasizing the importance of the early phases of a project and a need for establishing "behavioural norms" for the project team early on. In the present study, the interviewees recognized the pronounced need for open communication established early on already during the front-end phase of the project. However, as practices supporting the open communication among team members were not purposefully established within the teams in the early phases of the project, they never became natural, well-rooted ways of working within the teams.

Further, this study highlights the importance of exploring the individual level of ambiguity and uncertainty that the team members working in interdisciplinary explorative NPD projects are facing. Previous research on NPD has discussed uncertainty related to platform (design work for the project) and market (customer desires) [13] and ambiguity related to subject (product, market, process, and organizational resources) and source (multiplicity, novelty, validity, and reliability) [29] to name a few. Further, team-level factors to be taken into account in the demanding context of interdiscilinary NPD project has been well recognized in earlier studies [see e.g. 30,8,31] However, research on the individual team member and the different forms of ambiguity and uncertainty they must face in innovative project has been underrepresented in the existing studies.

Role ambiguity was brough up by majority of the interviewees. Role ambiguity did not only hinder utilizing all the capabilities of the team in an efficient way but also increased the need to control the work of other team members. Further, several interviewees were dissatisfied with their own contribution on the project as it was not clear what was expected from them. In the later development phase, on the other hand, as the team members had become more confident regarding their role, they were also providing more freedom to other team members in their work. Hence, unclarity in team member roles may have far reaching effects, and at its worst can lead to situations where the value of interdisciplinary team (wide range of skills, expertise, knowledge) is left unutilized. In the messy context of early phases of NPD work, shedding this unclarity is likely to be more effective when emphasis is put on sharing and understanding the perspective and feelings of the individual team members rather than focusing on e.g. formalized task allocation and role specification.

Further, the study showed the teams to have a strong *strive for consensus*, possibly in order to avoid potential conflicts that may occur if one's own point of views would be held on to more strictly. Edmondson and Nembhard [8] have noted that in cross-functional, interdisciplinary teams, team member diversity should foster creative tensions and disagreements that are mediated through collaborative communication and exploration which will result in more innovative outcomes. The risk, on the other hand is, that if these creative tensions and disagreements are avoided, deeper exploration and thus potential novel solutions might be left unseen and the value of an interdisciplinary teamwork unutilized. Thus, the limited participation of any team member means that valuable information and inquiry is lost and that unproductive communication can hinder learning and innovation [8], highlighting again the need for establishing structures supporting open communication among team members.

Finally, both of the teams were struggling in *balancing and iterating between abstract and concrete thinking* and with continuous experimenting, one of the key elements of learning [15] and a fundamental innovation process activity [32]. Earlier research on experimentation behavior [33] has found that in order to experimentation behavior to happen, one must be able to think both in terms larger strategic goals and at the same time recognize smaller, actionable, steps for reaching them. This includes knowing how to move forward with the idea and how to evaluate progress in order to ensure learning. In this study, interviewees were facing challenges in recognizing the smallest testable elements without simplifying the whole concept, and still staying open to explore different possibilities.

The present study thus helps to shed further light on the teamwork and individual team member requirements in interdisciplinary settings during the diverse needs of NPD project. While the small amount of participants all located in a university context limits the generalizability of the results, at the same time university setting in particular offers a fruitful context to explore the issues due to the prominent existence of certain elements, such as unfamiliar team members, fields and ways of working, leading to high level of uncertainty and ambiguity. The present analysis is the first step in a larger research that aims to create deeper understanding on the team dynamics and the requirements explorative projects set for the team as well as for the individual at its different phases. The researcher has already collected a richer set of longitudinal data of which the 13 interviews have gone through the preliminary analysis. The results of this first part open up interesting themes for future research, such as the effects of individual's role ambiguity to team atmosphere and teamwork and the requirements for experimentation approach in explorative projects.

Several practical implications to be taken into account in managing interdisciplinary teamwork of NPD project teams could be pointed out from the study. The results e.g. suggest that putting effort in the front-end phase on practices that support creating a desired atmosphere and ways of working in the team will benefit the team throughout the project. Further, early phases of the NPD project seem to be crucial also for utilizing all the capabilities of the team; the better the team is aware of all the skills, knowledge and capabilities of the team at the front-end phase, the better they were able to utilize all team members at the later phases of the project. As in interdisciplinary teams, team members usually are not familiar with the field of others, it is the duty of each member to make their skills, expertise and knowledge explicit at the early phase of the project. Further, the study highlights the importance of providing supporting structures for open communication and providing feedback among the team members. This is important for reducing role ambiguity in interdisciplinary, explorative NPD projects. Practices supporting open communication makes providing both positive and constructive feedback related to team members roles and

contributions easier and diminishes the pondering about whether one is doing things right or doing the right things.

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