I, Miao Wang, hereby submit this original work as part of the requirements for the degree of Master of Design in Design.

It is entitled:
Design as Communication in Collaborative Innovation

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Abstract

We live in a world where both strategic and operational advantages are driven by collaboration and sharing. To enable the collaborative innovation within a cross-functional team, transparent and efficient communication is necessary. Designers are trained to be proficient in communicating ideas through visual languages which can be easily identified and understood, naturally designers excel in describing and delivering information within a multi-disciplinary team environment. More importantly, being experts in divergent thinking from “naive” end-user perspective, designers prefer to bring creative ideas with comprehensive consideration of the product eco-system. However, in a collaborative working context, the value of design as communication media has not been well recognized because of the stereotyped view from outside disciplines as well as the individual weakness from the designers’ lack of experience in project lifecycle management. This study attempts to frame a coherent model by which the effectiveness of design communication can be fully executed into the collaborative innovation. Issues like how to influence team decision making by taking full advantage of user-centered design thinking and multi-media design implementations will be discussed. The model of integrating the design process into product and team development process will be addressed and applied in the empirical case studies in the area of medical technology invention. Primary design history files were recorded with a few semi-structured interviews of stakeholders from distinct domains.

Keywords: Collaborative Innovation, User-Centered Design, Cross-functional Team, Design Communication Model, Organizational Decision-Making
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1. Background

The innovation capability within a team significantly relies on inputs from the experts participating on the team in -knowing why, when, where, what, and how to innovate. The interactive communication within this information flow leads to a prevalent trend, so called “Collaborative Innovation” (Chesbrough & Schwartz, 2007). Since then, collaborative innovation approaches was connected with all the stakeholders – including internal team customers, suppliers, vendors and even competitors.

However, this diversity of organizational backgrounds potentially enhances the risk of conflicts and project failures (Tidd et al., 2001) conversely it may initiate chances for creativity (Ritter & Gemünden, 2002). Meanwhile, from project management aspect, there is naturally a lack of support methodologies and computer-aided systems for the team decision-making in the early phase of the product development process (Stacey et al., 2000; Zha, 2003), and this diminishes the overall efficiency of the team collaboration for creativity.

This study examines design as communication from a perspective of cross-functional team collaboration from Medical Device Design of a representative project in the University of Cincinnati’s Medical Device Innovation and Entrepreneurship Program (MDIEP). The thesis is structured in four chapters. First, the research issue results from the empirical projects and literature review are addressed. Second, the research methodology and its implementation within case studies are illustrated. To be continued, findings from the case study are analyzed and presented. The study ends with conclusions and implications for further research.
2. Research issues: communication barriers in collaborative innovation

2.1 A trans-disciplinary perspective of collaboration

Product development is a project-oriented practice of dynamic synergies coordinating fundamental disciplinary tenets of function (engineering), appearance (industrial design) and value (business) (Privitera & Johnson, 2009). Each discipline performs different missions based on distinct information they operate with its own skill set. Adequate mutual accountability is needed to create the orientation for organizing team members to achieve their shared goal. To the contrary, the unstructured collaboration deducts the shared goal and appeals for minimal dependency from participants. By analyzing how communication patterns and behaviors affect collaborative innovation, the study refers design communication to three levels, including individual reflection, team development and project process.

2.2 Identifying the gap between two hemispheres

In cross-functional team, the disconnections from the hemispheric differences were distributed into the following three communication gaps within collaboration:

1) The media gap: whether design requirements interpreted from users or design solutions conveyed to other team members, the information needs to be operated and converted repeatedly into general symbols. How to maintain the initial meanings through symbols transmission is issued.

As first gap stated above, the media for communication can be depicted as face-to-face and electronic formats. Today, available media for asynchronous communication are becoming extremely large and powerful; nevertheless, research is still scant in integrating these media into the product development process in order to effectively guide the team making right decisions.
2) The process gap: to leverage the technical efficacy, aesthetic pleasing and market perception into one comprehensive product innovation process is always challenging in terms of their respective approach to troubleshooting. How to coordinate synchronous and asynchronous communication in different stages of development to stimulate design progress is discussed. Research in the innovation process field has sought to address the determinants of innovation and success of organizations in various ways; however, they are inherently limited to methodologies and theories level. To date, there is scant attention to the practical implications for which specific model or specific level of detailing is necessary for which goal under which circumstances. This reveals the essential issue in decision-making section derived from complication of team development.

3) The performance gap: although it’s team leader’s privilege to motivate other members, breaking down cultural barriers for an effective collaboration, the decision-making appears to be an interrelated task which involves all entities’ efforts. The team leader must address methodologies in how to facilitate the communication within the team towards a high efficacy of a joint accountability.

Research has revealed that team development relies upon the maturity and cohesion that a team performs over time as all the members interact, knowing one another and configuring relationships and accountabilities in the group (Sarker & Sahay, 2002; Gersick, 1988). Moreover, a commonly known as the four-stage model of team development was proposed by Tuckman in 1965. This four-stage model is consisted of forming, storming, norming and performing in sequence before an effective team achievement. The subsequently revised model by Kur (1996)
promotes the iterative feature of team development compared to the sequential development via adding a fifth stage— adjourning (Figure 1). For this study, Kur’s model (1996) was selected as the foundation to explain how cross-functional teams develop over the project duration from forming to performing because it corresponds with the agile product development process that is widely adopted into the industry.

Figure 1  *Tuckman’s four-stage model vs. Kur’s five-face model*
3. Research method

This thesis research follows a phenomenological paradigm since it involves into a comprehensive context pertaining to methods such as ethnography, task analysis, and human factors, etc. within the cross-functional team collaboration. Therefore, the format adopted a case study as the major research methodology due to its in-depth investigating character which fits in a contemporary phenomenon in its real-life setting (Yin, 1994).

Medical Device Design was developed by an academic team including one industrial designe and two biomedical engineers. Both internal (academic advisors) and external (university hospital surgeons) advisory board assisted the team in decision making and project management. In the case study, teamwork flows were recorded while synchronizing with new product development procedure within three product lifecycles. Each of these three lifecycles (Model A/ B/ C) follows the typical method and process of Medical Device Innovation and Entrepreneurship Program (MDIEP) coordinating with School of Business, Design and Biomedical Engineering in University of Cincinnati. Data was generated through the use of records from a paper-based design history file (DHF), a web-based collaborative environment (SharePoint) and every other communication messages delivered by email or SMS. Additionally, a few semi-structured interviews within each lifecycle were also enclosed in the database. All of the initial data sources were later imported into a coding-based content analysis software NVivo. Moreover, cognitive maps were adopted to facilitate the data presentation of building up the linkages among each design component for the entire system. Ultimately, a model for this medical device co-creation was documented as key findings in conclusion chapter.
4. Case study findings

4.1 The communication media and information flow

Communication media ranges from paper based sketches to digitized 3D models. In the earlier stages more handcrafted work was completed and aligned for later modifications in a digital modeling tool. Since there are compatibility issues among separate media (e.g. 3D model built in Rhino was not recognized by Solid Works), designers must have the ability to rapidly switch design software to creatively bridge the gap other than conceptual design explorations. Additionally the keeping records of all the communication activities benefited tremendously in long-term product development project, regardless of content, and especially if it refers to team decision making for the final result or ongoing in-depth design.

4.2 The innovation process

Inspired by the waterfall model design process in MDIEP (see Figure 15), the study also implemented the sequential design process regarding the dominance of individual participant in different stage of this collaborative innovation project. Findings relating to the topic are addressed as below:

1) In the early stage of product development, the creativity was stimulated by the difference between each domain with distinct perspectives on the same facet of the problem. Designers gear up the concept generation activity by inspiring the team with his/her divergent design thinking model (see Figure 2 Designer thinking model).

2) To the phase of development, all the inputs from diverse sources needed to be exchanged and/or translated instantly for decision-makings to keep the project moving forward. A challenge for designers to shut down their creating flow, while engineering function tended
to move to the next step before the deadline because of their (engineering) need to follow up on actionable criteria for design decision making based on their scientific method analysis (see Figure 3).

![Linear designer thinking model (infinite divergence)](image)

**Figure 2**  *Linear designer thinking model (infinite divergence)*

![Circulatory scientific method (schedule control)](image)

**Figure 3**  *Circulatory scientific method (schedule control)*

3) The MDIEP team executed SurgiSIL, a project provided an ideal model for understanding the status of communication by tracing the information flow. Figure 4 illuminates a task-oriented process of collaborative innovation driven by decision-making for each cycle of the task achievement.
4.3 The structured team development

In general, team members all agreed with the sequential stages tracing forming-storming-norming-performing-adjourning for team development synchronizing with the product design process. They also verified that conflicts often emerged in transitions that the project was moving from one trade of work to another, or the team was restructured due to the arrival/ departure of members. Furthermore, the main advantage of the structured team is supposed to manipulate expertise in both product development and organizational management throughout the effective communication.

Figure 4  *Medical Device Innovation Process Map*

![Medical Device Innovation Process Map](image)

Figure 5  *Communication roadmap in integrated process model.*
5. Conclusion

The aim of this research is to investigate how the role of design as communication affects collaborative innovation, by tracing on the cyclical processes of team structuring and project development. The evidence demonstrated that these two dynamic lifecycles intertwined and played a separate role in each stage of the innovation process. Therefore, the integrated process model for collaborative innovation was proposed as Figure 5 illustrates. In this illustration, design plays a pivotal role as facilitator assisting to move the team from one development phase to another. Also, a couple of meaningful results have been yielded by this research study as following statements:

1) The nature of design as communication: Within all three design iterations, 43% of the project time was used for communication, while 48% of all time was spent in design drawing, modeling and modifying, etc. The role of design inherently played a coordinator between problems identification and solution implementation.

2) Task-oriented and structure-driven process: Communication barriers were found in the case study occurring in transitions of task altering and group restructuring. Being aware of the organizational influence on collaborative innovation, team members are capable of optimizing available resources to execute their best performance.

3) Self-reflection: Findings from the case study demonstrate the strong sense of learning from each other was motivated by conflicts, including the differences from fundamental principles and methodologies, misunderstanding of the intentions by distinct language contexts, or arguments from respective perspectives. The individual designer should be able to adapt his/her capability into the given condition quickly. This flexibility is more than what can be
taught in class, and must be learned through interactive working experience and
self-reflection.
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