How Do Customer and User Understanding, the Use of Prototypes and Distributed Collaboration Support Rapid Innovation Activities?

Laura Kanto[1], Pekka Alahuhta[1], Kirsi Kukko[2], Jussi Pihlajamaa[1],
Jouni Partanen[2], Matti Vartiainen[1], Pekka Berg[1]
[1]Aalto University, Department of Industrial Engineering and Management, Aalto University School of Science, Aalto, Finland
[2]Aalto University, Department of Engineering, Design and Production, Aalto University School of Engineering, Aalto, Finland

***Abstract*--Speed in product, service, and business model development is widely recognized as a source of renewal and growth both in theory and in practice. This study theoretically and empirically explores how the innovation process can be better managed and accelerated by (1) constructing customer and user understanding, (2) utilizing distributed collaboration, and (3) utilizing different prototyping methods in the front end of innovation processes. Previous studies have not addressed the speed of innovation process through these lenses.**

We expect that by integrating the knowledge of customers into the innovation process, firms are more likely to rapidly sense emerging market opportunities. We suggest that the distributed mode of collaboration embraces teamwork among individuals with diverse backgrounds and expertise. We expect this diversity to nourish team creativity and possibly enhance team performance. We lastly expect that using different physical models will enhance the processes of sharing, describing and developing innovation. In particular, 3D printing has made it possible to quickly print a physical model that people can experience: they can feel its surfaces, weight and mechanical functions. We propose that the combination of these perspectives will lead to new insights in innovation management and increase innovation speed.

I. INTRODUCTION

A. Innovation speed

> *The innovation speed is the time elapsed between initial conception and ultimate introduction of new product into the marketplace [43].*

In the 1990s, it was already written that the utility of speed is the result of increasing global competition, exponential advancements in technology, and the frequently shifting nature of customer demands (e.g., [6], [65], [97]). These factors are combined in many industries to produce shorter product life cycles and thus create the need for faster product development. The ability to compress time is a unique capability that may confer a sustainable competitive advantage [43]. Goktan and Miles [35] have written that firms that are able to survive have found ways to simultaneously deliver radically innovative products and shorten product development time.

In a recent literature review, it was found that innovation speed has been studied primarily in the new product development (later: NPD) arena [26]. The main topics in this arena have been the ways of reducing the time from idea to launch rather than increasing the speed from idea to launch. It has also been found that most of the existing studies have focused on the project level [1], [12], [37]. From prior research, it was found that three things in particular contribute towards improved perceptions of satisfactory cycle times: (1) the development of a formal new product development strategy, (2) the creation of an appropriate climate for innovation, and (3) the use of cross-functional teams [72]. The presence of systems and structures that facilitate the rapid exchange of relevant information between functional areas is the key antecedent of fast NPD [63]. Additionally, increasing the frequency of prototyping and testing enables a "fail early" philosophy, thereafter increasing the innovation speed [26].

A method that follows a "fail early" philosophy and uses prototyping and needfinding is design thinking. Design thinking is a set of practices for creating innovations. Innovation by design thinking involves meeting people's needs and desires in a technologically feasible and strategically viable way [13]. There are also other innovation methods and innovation management tools that are considered to accelerate the innovation process, e.g., co-creation [78], employee-driven innovation [44], and scenario and foresight methods (e.g., [90]).

B. Research questions

In this study, we focus on the ways in which innovation process can be managed and accelerated. We depict three rapid innovation practices that convey the potential to increase innovation process speed: (1) customer and user understanding, (2) distributed teamwork, and (3) different prototyping methods. We combine these three aspects into the category of rapid innovation practices because each of them is found to have a positive effect on innovation speed. However, previous studies have not addressed the speed of innovation process by combining these lenses even though this combination could produce a new approach to the innovation arena. Customer involvement positively affects the operational outcomes of the innovation project, i.e., technical quality and innovation speed [15]. Endorsing early prototyping and testing makes it possible to quicken innovation speed [26]. Distributed work processes allow the engagement of the needed expertise in the task at hand [54], [55]. Together with a synchronous mode of communication [94], the distributed work conveys a potential towards increasing the innovation process speed. This research can be seen as a baseline study and declaratory "big picture" from three research aspects. Fig. 1 shows the triangle of the research themes.

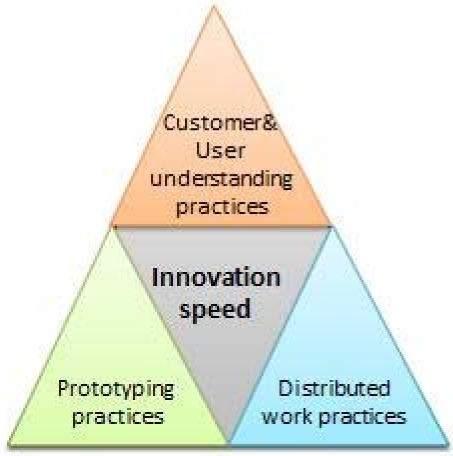

Figure 1 Triangle of rapid innovation practices

C. Context of the research

Fig. 2 below depicts the contextual frame of this study. The contextual frame covers business intelligence, the innovation process and its different phases and outcomes. As indicated in Fig. 2, in this study, we direct our focus toward the front end of the innovation process. Therefore the front end of the innovation process creates the context for this study. The diversity of innovation process outcomes – goods, services and business models – reflects the variety of their development methods and practices.

Offering

Innovation is a process initiated by the perception of a new market and/or new service opportunity for a technology-based invention that leads to the development, production, and marketing tasks that strive for the commercial success of the invention [68]. This definition from the OECD covers two central issues of innovation. First, innovation includes the whole process starting from invention through development, production, and market introduction and finally ending with commercial success. Secondly, an iterative process also means that innovation includes both an introduction of new offering and later its incremental improvements [31]. Thus, the initial idea, i.e., the invention, is turned into innovation via the process of development, production and successful market introduction.

The concept of an offering innovation refers to an innovation that might include a product, a service, or a business model. Goods are sold by an enterprise to its customers. Goods are the determined type of offering that is engineered, discrete and physical. Ulrich and Eppinger [93] introduce several variants of goods that correspond to the following elements: market pull products, technology push products, platform products, process-intensive products, customized products, high-risk products, quick-build products and complex systems. Apparently, service innovation differs from innovation in physical goods (products). Because service offering is more or less inseparable from its production, the concept of “service innovation” can be understood to cover both innovations in service content and those in the production system. The outcome of a development process is the pre-requisite of a service [22]. The concept of a business model has been nearly absent in the academic literature until the past ten years [3], [64], [71] [89]. The business model concept remains under-conceptualized [89], and no generally accepted definition for the concept exists [64]. To conclude, it can be said that a business model represents the “money-earning logic” between a vision, goals and objectives and the organization, processes and a workflow. Thus, a business model ties together the planning and implementation activities in the organization.

Front end of innovation

The front end of innovation is defined in this study as the period of time in which an opportunity is first considered worthy of further ideation, exploration, and assessment. The front end phase ends when a firm decides to invest in the idea, commits significant resources to its development, and launches the development project (e.g., [18], [46], [85]). The importance of the front end lies in the fact that when performed effectively, front end activities can directly contribute to the success of a new offering [17], [21], [62]. The front end phase nourishes new goods, services or solutions to the development project phase by developing defined opportunities and ideas into new concepts. The outcome of the front end phase is a well-defined offering concept clear development requirements and a business plan aligned with the corporate strategy [47].

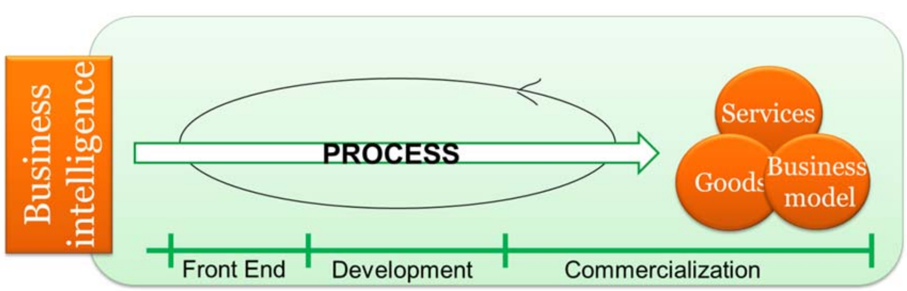

Figure 2 Contextual frame of the study

The front-end phase has a very strategic nature because important strategic decisions related to target markets, customer needs satisfaction, value propositions, expected product price and product costs, the main functionalities of products, and the predominately used technologies, for example, are all made at this stage [9], [97]. However, many firms acknowledge a serious weakness in the front end of their innovation processes [45]. This is not surprising because the front end phase represents the weakest and most troublesome phase of the whole innovation process [76]. At the same time, it provides one of the greatest opportunities with which to improve the overall innovation capability [48], [66], [102].

II. THEORETICAL BACKGROUND

A. Customer and user understanding

Researchers have emphasized that to achieve competitive advantage, organizations need to involve customers and users who may not be customers in the development of a new offering [22], [77]. Gherardi [32] shows that by managing the knowledge of their customers, firms are more likely to sense emerging market opportunities before their competitors and to more rapidly create economic value for the firm, its shareholders and its customers. Customer involvement is not considered to predict the market performance of a new service project [15]. However, this is not to say that customer involvement in new service development has no value. As demonstrated in Carbonell's [15] study, customer involvement has an indirect effect by having a direct effect on market outcomes and by positively affecting operational outcomes, i.e., technical quality and innovation speed.

The market orientation is not sufficient by itself for successful innovation processes in technology firms. There is also a need for organizational learning [83] to construct customer and user understanding from the information collected in a market-oriented culture of the firm. Customer understanding can be seen to be a result from market-oriented organizational learning [67].

Another way of thinking about learning is through participation in practice. The concept of "practice" refers to a type of activity that consists of several elements: bodily movement, mental activities, objects and their use, contextual understanding, normative understanding and emotion [79]. In everyday practices, learning takes place through the flow of experience, with or without our awareness of it [32]. In the innovation context, practice would refer to the shared understanding of corporate life (in this case, the understanding of customer and user knowledge) and the "corporate kind of creativity" and praxis would include ways of presenting, commenting, refining and evaluating ideas (in this case, knowledge about customers and users) [57].

To reach a more in-depth understanding of the customer, it has been noted that the goal should be as closely aligned as possible with the customer's real life during the different phases of the innovation process [24]. Lettl argues that firms need a special competence on the organizational level to systematically integrate customers into the innovation process [58]. Gruner and Homburg suggest that the intensity of customer interaction varies in different stages of the innovation process [39]. However, previous studies have not paid sufficient attention to the types of customer involvement in different innovation process activities [20]. Moreover, research on how to methodically integrate the customer and user understanding in (service) development processes is scarce [23].

B. Distributed collaboration

Distributed work involves knowledge work that is performed by collaborating team members in multiple locations and contexts [4], [10]. We suggest that collaborative, distributed work can convey a significant potential to enhance innovation speed. This may be a possibility, though the available empirical research shows mixed findings about how distributed collaboration influences outcomes such as creative and innovative products and services. In their study, Martins and Shalley found that differences in nationality had a strong negative direct effect and interacted with differences in technical experience to affect creativity [60]. Differences in sex and race did not significantly affect creativity. On the other hand, Thatcher and Brown noted that when the ratio of mediated communication to face-to-face communication is high, there is an overall positive impact on creativity [88]. The present literature does not fully know what variables of distributed collaboration are related to positive impacts. However, when creating and designing new products and services, the distribution of a team's members into many locations is often a necessity; the expertise and knowledge is unevenly distributed in a company. This type of co-work from far may not be avoided; therefore, it is important to find technologies and practices to enhance distributed collaboration.

Creative and innovative actions can be considered collective efforts [74]. Instead of experts working in solitude, innovations inside an organization often occur in communities that organize themselves according to the task-related knowledge [55]. These communities can also span outside the organization's borders, thereafter forming collaborative networks that exist within or between corporations [27], [28].

The distributed mode of collaboration is likely to embrace the heterogeneity or diversity among team members. This diversity arises from the differing technology and activities utilized by team members as well as the physical location, culture and distance between the team members [38]. The diversity between team members is considered as a necessity for a creative team [54]. Team diversity may lead to constructive conflicts between the team members [53], thereafter encouraging the discussion of creative ideas. The heterogeneity between team members also fosters idea diffusion within the interacting teams while embracing mutual learning between the team members [8].

Additionally, cultural diversity among team members, in conjunction with separate locations and differing individual expertise, may enhance creativity during the innovation process [34].

On the other hand, certain hindrances emerge when a team is engaged in a distributed collaboration. First, knowledge can be seen as "sticky": information is costly to acquire, transfer and use in a new location [95]. Several studies (e.g., [34], [42], [75]) report conflicts that occur within distributed collaboration settings. When an innovation team engages in the distributed mode of operation, the team's environment lacks artifacts that embrace social engagement and symbolic cues that are essential for the interaction [30]. As concluded by Gibson and Gibbs, simply bringing people with required knowledge and skills together does not guarantee the ability to work effectively and innovatively across their differing contexts and environments [34].

Virtual worlds

Distributed innovation activities are realized via asynchronous and synchronous collaboration channels [94]. Asynchronous collaboration channels create platforms for knowledge sharing by accumulating data storage. Synchronous collaboration channels provide tools for collaboration between the innovation agents. 3D virtual worlds are emerging collaboration environments that allow the combination of these collaboration channels [29]. Virtual worlds are defined as communication systems within which collaborating users share a common three-dimensional digital space despite occupying remote physical locations. Users can manipulate objects in digital space, navigate around the space, and communicate with other users using 3D graphic avatars as their transformable digital self-representations [100].

Virtual worlds are known to convey the potential towards creative activities [5]. Avatars as user representations, the potential to change users' frame of reference, a sense of co-presence, immersive potential, multimodal communication, rich visual information, simulation capabilities and additional tools are suggested as the virtual worlds' potential affordances that can prime creative collaboration [2]. Meanwhile, virtual worlds have been noted to convey the potential for collaborative design [81] and distributed problem-solving [56] platforms. Previous research has somewhat addressed the potential of virtual worlds in activities that are related to the innovation process [49], [50], [51], [80], [96]. Building on this existing research, it is relevant to inquire about whether virtual worlds can also contribute to enhancing the speed of the innovation process as well as the management of the innovation process activities.

C. Prototyping

Prototyping has long been a popular method in engineering and design practice [93]. The main reason for this popularity is that prototypes will provide the means of examining design problems and evaluating solutions [41]. Other reasons include visualization, editing, the ease of communication, functionality testing and the proof of concepts [11]. Finished-looking prototypes can also be used for marketing purposes.

While prototyping has a long history in the conceptualization and modeling stages of the innovation process, tangible prototypes that are intended to represent real opportunities have rarely existed in the front-end stage, much less at the vision stage. In the front end, one particular problem is the articulation of complex knowledge and complex problems [86]. Thinking happens both with the hands and with the mind [52], so it is important to capture and share ideas via physical models. For example, Yang emphasizes the importance of early stage prototyping, citing that more time spent on prototyping during earlier stages yields better designs [99]. Surprisingly little is understood about the application and culture of physical mockups and prototypes. Culture plays a critical role in shaping designer beliefs about the value and use of prototypes, and less is understood about external influences and environmental factors that foster the initiation and development of prototypes [16]. Iterative and parallel prototyping in the front end of the design process follow the "fail early, fail often" philosophy mentioned in the introduction, which can help speed the innovation process.

In the literature, prototypes can be categorized and characterized in several different ways: (1) function [16], (2) function and the stage of product development [92], (3) the stage of development [99], and (4) purpose [41]. Despite this pigeonholing, paper mock-ups, LEGO® SERIOUS PLAY™, 3D-printed objects and virtual simulations area all valid prototypes if they convey to their users what they were meant to prototype as easily as possible in the appropriate stage of the innovation process. Prototypes are not self-explanatory, so clarifying which aspects of a prototype correspond to the eventual artifact and which do not is a key part of successful prototyping [41]. Rough sketches and prototypes that are highly abstract, built from other material, and able to be held in the hands leave space for big, paradigmatic changes to a model. Fine sketches and high-resolution renderings (e.g., CAD models) yield parametric, small changes in a model [14]. In this research paper, the lens through which we view prototyping is 3D printing.

3D printing

In modern product development, data is always stored and transferred in a digital form [7]. Objects that are designed by computers can be automatically made by using 3D printing technology, which is more a popular term than the industry standard term of Additive Manufacturing (AM) technology. All commercial 3D printing technologies make three-dimensional objects out of thin two-dimensional layers by stacking them up to form the final object. The layer-by-layer approach is very suitable for complex geometries [87]. 3D printing is considered to be distinct from traditional machining techniques, which primarily rely on the removal of material by methods such as cutting or drilling (*subtractive* processes) [98].

The field of 3D printing contains many digital tools for rapid innovations. For example, Computer Tomography (CT) or Magnetic Resonance Imaging (MRI) is used to capture the geometry. Very recently, image analysis technologies have developed so much that regular digital cameras can be used for 3D scanning. The end result is a digital file of a shape that can be either printed or further engineered with a Computer Aided Design (CAD) Program. The ability to create three-dimensional objects directly from digital data allows designers to print out 3D representations of their designs for form, fit and functional testing during the innovation process [87].

Having the data available digitally early in the innovation process should also lead to benefits later, especially when beginning the transfer to production. Additionally, financial risks related to new product development can be reduced with digital production technologies [73]. In addition, having data available digitally early enables and supports distributed collaboration when, for example, the same prototype can be 3D-printed and analyzed in different locations and then discussed and reflected within a virtual world.

III. CASES AND FINDINGS

In our study, we have adopted a case study-based research approach (see, e.g., [25], [101]). The focus of our case study was a world-leading forestry corporation that is located in Finland. The company is well established, operates in business-to-business (later: b-to-b) markets, and employs over 800 people. The company has declared to be committed to continuous improvement. This applies to its offerings and to its way of working. The company's goal is to be a customer-oriented company, which is also emphasized in the company's strategy. The data used in the case study were collected in 2013 from four different sources presented in Fig. 3. The sources were interviews and observations of one workshop, one virtual meeting and one face-to-face meeting.

A. Case I: Customer and user understanding

Study design

We conducted an interview to study how customer understanding is constructed in the case company. The research data were collected through 11 semi-structured interviews (presented in Fig. 3) lasting from one hour to one and a half hours. The interviews were arranged during a time period ranging from September to October 2013. No pre-material was sent to the interviewees beforehand. All interviews were recorded and transcribed. The data were analyzed according to the procedures developed for case studies [25].

Our interviewees represented the case company's Finnish and European operations. We interviewed three workers from the R&D department, two from production, three from the customer service and two from marketing and sales. From each department, one director (from R&D two) and 1-2 manager or specialists were interviewed. As a supplementary material, we utilized memos from discussions with the case company's VP of Product Development. In addition, we interviewed one person from the case company's major supplier. The interview topics included offerings, customer and user knowledge and communication, customers' and users' roles in innovation process and internal collaboration between R&D and other departments.

Findings

The interviewees were first asked about the company's offering portfolio. All of the interviewees had similar knowledge about the offering portfolio.

"We have three types of products."

The question about the possible services compelled the interviewees to think about the situation. It was clear to all of the interviewees that the company has services in their offering portfolio, but the business logic was unclear. The service offering is based on customer segmentation – services are offered to customers in the two highest segments and no fee is charged from the service itself – the price of the service is incorporated in the price of the product.

"I was wondering if we have any service, just service. I suppose all of our services are tied to the products."

The case organization operates in a b-to-b environment. In the company's statements, they talk only about their customers, not users. In addition, for the interviewees, it was not common for them to think about the users of their products, at least not the end users of the value chain.

"The ordinary consumer does not appear in my work in any way."

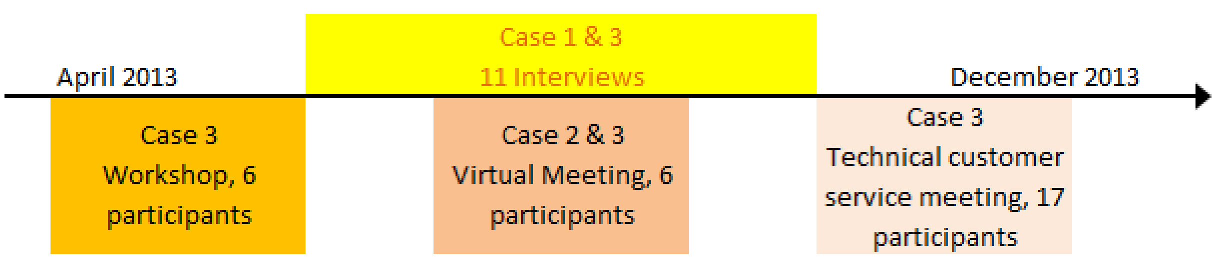

Figure 3 Data sources

"For us, the user is really the machine and the staff of the machine."

Still, many of the interviewees thought that they should actually think about the different types of users in the value chain because it could bring some new ideas to the R&D department and better and even more profitable products in the end.

"We should more and more really think about the end users and not only that we are the material suppliers for the intermediaries."

The case company has been using a structured customer responsibility chain for over 10 years. Every important customer (approx. 40) has their own key account manager and a technical customer service person. In addition, each important customer has his or her own dedicated contact person on site, and communication is conducted almost daily. Although communication through the chain is considered to work well, it has been noted that from the strategic and innovation viewpoint, it is not sufficient that only the sales function communicates with the customer. Therefore, the company has changed the process of the structured customer responsibility chain so that the top management also communicates with the customer's top management at least yearly. The R&D managers are also connected with customers.

"It is considered that it is good to have connections to a customer's direction on different levels. Today, it is no longer enough to have sales cooperation with the customer. There is a need for cooperation with our top management and customer's management."

All of the information from a customer (official meetings, unofficial meetings, etc.) was gathered on a CRM platform for the previous 6 months. At the moment, the information is not visible for the R&D department, but there are plans to open it for a few people in R&D. After opening the information, R&D people are also supposed to input their customer knowledge onto the platform. The interviews revealed that there is no agreed-upon process for analyzing all of the customer information collected within the CRM system.

"One is allowed be in contact with the customer independently, as long as one remembers to report to the Key Account Manager and CRM."

Customer knowledge and some user knowledge are gathered annually through a customer satisfaction survey, which is conducted by a consultant. The survey information is reviewed in a workshop. If needed, more extensive discussions concerning the information are arranged in smaller groups. This current mode of operation was considered sufficient according to interviewees. In addition, general trends are looked on in the business intelligence unit in a formal way, even though key account managers have the biggest role in the collection and interpretation of customer knowledge. This role has been considered as a problem.

"The salesmen are such that they do not have the patience to sit still for more than five minutes. If one starts talking about some projects whose results may be seen in five years or so, it is useless to imagine that anything is left in their heads."

In the company's innovation process, a customer has a very important and almost crucial role. Noticeably, all members of the R&D department do not concur with this notion.

"Nothing is performed without the customers' need."

"It is not always self-evident for all, especially in R&D, that we should develop primarily just those things that customers have indicated."

To strengthen the customer focus, the company has created a format in which R&D people (occasionally in addition to people from other functions) from the case company and customers meet and have time to brainstorm the next R&D projects together. This is seen as the most efficient and systematic way not only to gather new ideas but also to strengthen the partnership with the customer. Some interviewees also had some doubts about the originality of the ideas gathered using this format.

"That's really just that the thoughts that have been sown in previous presentations are put there as their [=customers'] ideas. It is the way in which we obtain the customer's voice so to speak, but really it's mainly and very often, however, those same things that we have already thought that we should do."

From the experiences that the interviewees had, it can be concluded that the company has already made some good changes to foster the rapid construction of better customer understanding by strengthening the connections with customers on different organizational levels by taking a CRM platform in use and by conducting the new ideation format with important customers. There is still a need to strengthen the cross-functional communication and cooperation inside the company, especially between the R&D and sales and marketing departments. At the moment, there is no cross-functional team if the development project is not directly a customer project.

"Yes, in the early stages, the sales and marketing should and must be involved if it is a new product development project in question."

During the interview round, all of the interviewees expected the forthcoming first meeting (after a long time) with R&D, sales, sales support and marketing. After the meeting, the development manager said that the meeting had not fulfilled all of their expectations (not listed), as the planning and management of the workshop were not performed at a sufficient level.

B. Case II: Virtual worlds

Study design

We conducted an experiment to study the virtual worlds' potential to act as a platform for innovation and design collaboration. The following section describes the experiment, including the test bed, research setting and preliminary results.

The experiment was conducted in the case company. The corporate VP of product development invited seven employees to attend a virtual world meeting. All of the employees were experts and managers with varying background and expertise. The employees were located in different corporate sites in Finland. The meeting's purpose was to brainstorm potential application areas for 3D-imaged pulp models. The meeting's purpose was communicated to the attendees in the invitation.

Six of the invited attendees took part in the interaction session. In addition to them, two members from the research team attended the session. One of them provided technical guidance and facilitation in operating the virtual world, whereas the other acted as a silent observer. The interaction session used a novel 3D virtual world collaboration space (offered by Immersife Terf Inc.).

The experiment lasted nearly 1.5 hours. Data from the experiment were collected from three sources. The experiment, including audio and visual channel communication, was (1) recorded. Additionally, a research team member (2) collected field notes during the meeting. Lastly, (3) a survey assessing the interaction session was handed out to the session attendees. The attendees were asked to fill out the survey immediately following the meeting.

Results of the experiment

The interaction experiment included the following segments. In the beginning of the meeting, the attendees gathered in a virtual "lobby." The meeting facilitator ensured that all attendees were technically able to use the virtual world. From the lobby, the participants moved to observe three artifacts. The artifacts included two three-dimensional representations of pulp samples that were scanned to a three-dimensional format and a 3D-pdf file of a mock-up object. The 3D-pdf file format allowed users to annotate, rotate and change the size of the mock-up object. Fig. 4 depicts a screenshot from the artifacts (annotated with 1 and 2) and avatars (annotated with 3) that are virtual-world representations of the collaborating experts.

In the meeting, the corporate VP shortly introduced the artifacts and asked the attendees to brainstorm possible scenarios and use cases for the artifacts. The attendees were also asked to devise improvements that could enhance the usability of the products.

Secondly, the attendees were asked to brainstorm the virtual world's potential application areas and possible use cases. The attendees used Post-it notes to write down their ideas. The ideas from each Post-it note were then discussed together. After the discussion of virtual world's application areas, the attendees were free to express their thoughts concerning the meeting and its content. When the discussion ended, one of the research team members ended the session. After the meeting, users filled out a survey concerning their personal experiences of the virtual-world interaction.

Six session attendees answered the survey. In the survey, five out of the six attendees indicated that they had never used a virtual world before the meeting. Nevertheless, the outcome of the session was considered good (4.0 from scale 1 to 5). Correspondingly, the overall performance of the team was perceived to be nearly excellent (4.18 from scale 1 to 5). The attendees also indicated a fair level of perceived engagement in the meeting (3.6 from scale 1 to 5) and considered that the virtual world provided fair opportunities for all to participate in the collaboration.

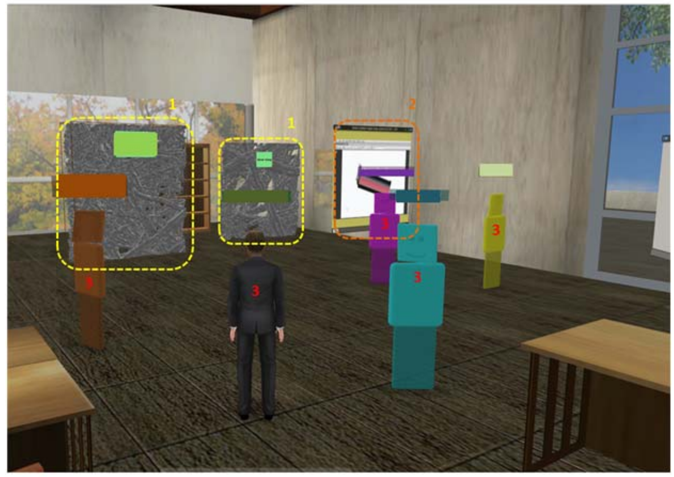

Figure 4. A screenshot from the virtual-world interaction session

The recorded interaction session was transcribed and analyzed by one of the members of the research team. The transcribed session was divided into turns, i.e., an action switch between the participants and their speech. The turns were coded according to their contents. The coding revealed that 59 of the session's 449 turns included ideation activity. From these turns, the emergent ideas were primarily related to (1) the improvement of the presented 3D samples, (2) the utilization of the virtual world in the daily activities within the corporation and (3) the improvement of the user experience of the virtual world. Even without a point of reference, the aforementioned finding signals an intensive ideation that occurred during the collaboration.

This case example introduces a distributed innovation activity that occurred in a virtual world. The users, being novices with the virtual world interaction, performed surprisingly well in the novel collaboration setting. Added to their personal insights of the collaboration's success, the output of the ideation was extensive.

C. Case III: 3D printing

Study design

Before this study, the case company had engaged in research where a Computer Tomography (CT) scan was used to capture the geometry of 1 mm x 1 mm sample of pulp. The results of the CT scan were given to our research group, formatted to a .stl file and then printed using a Zprinter printing machine.

3D printing is the only method to accurately prototype pulp samples. Pulp fibers form such complex geometries that it makes all other methods practically impossible.

A 3D-printed pulp sample was introduced into a workshop where company representatives and researchers negotiated in which direction this study would proceed. This first print was then given to the company representative who showed it inside company.

Prototyping and 3D printing were also included in the customer understanding interview round, which is introduced earlier in this chapter.

The participants collaborated in a virtual world (see case II) and innovated how to improve physical 3D-printed samples (Fig. 5).

Figure 5. A 3D-printed pulp sample that circulated in a technical customer service meeting

The final step was a technical customer service meeting. Seventeen participants from the case company's technical customer service department attended the meeting. During the meeting, the research group observed 30 minutes of debate on 3D printing. Most of the participants had seen the first 3D-printed pulp sample. Approximately the same number had heard approximately 3D printing. The meeting started with a short introduction to 3D printing followed by a round of comments and ended in free discussion. Four new 3D prints of 5 different pulp samples were printed in different sizes and combinations (e.g., one of print was in color, one 3D print had two different samples printed side by side to better compare them, etc.) to spark the discussion. The samples were circulated so that participants were able to touch and feel them. The discussion topics were (1) how to improve and develop pulp samples, (2) where the samples could be utilized and (3) any issues raised concerning 3D printing. Data from the meeting were collected from two sources: the meeting was video recorded, and additionally, a research team member collected field notes during the meeting.

Results of the experiment

As a forestry corporation and pulp manufacturer, the case company had not experienced prototyping to a great extent. Their first comments, though very politely phrased, indicated that they have no use for 3D printing. Luckily, some of the corporate vice presidents were open-minded and agreed to try to print out the first pulp sample. This inspired so much positive interest both in workshop and inside the company that the research group was encouraged to continue this part of the study.

During the customer understanding interview, four out of 11 interviewees also discussed this first 3D-printed sample. It had been shown at the 2013 London Pulpweek and garnered attention.

"Our image is that we know our product better than anyone, that we are innovative, and this (3D printing) is a way of strengthening it."

"I think that one thing people will remember from this occasion...is these 3D prints."

Of course, all attention was not positive. Several comments raised valid points for improvement.

"The hardness of the 3D-printed sample caused some consternation. Shouldn't pulp be soft? And it's so heavy."

The case company commissioned five more pulp samples to be scanned with Computer Tomography for further 3D printing.

After the virtual meeting, enough interest was raised that one of the six attendees even contacted the research group to obtain more information about 3D printing. He indicated that he would study the topic and use the information for a specific R&D meeting.

The 3D printing part of the technical customer service meeting was very fruitful. The participants, even though some of them were new to the concept of 3D printing, were very innovative in finding ways to utilize the printed sample. Out of 17 participants, only one skipped her turn during the round of comments. From the collected data, 34 different ideas or instances were counted in which to use 3D-printed pulp samples or how to improve them. It was thought to be good tool with which to communicate and interact with customers and for training purposes.

"The structure of pulp is difficult to convey to customers, especially when you compare it to other pulps…I sometimes try to use spaghetti metaphors, but often it doesn't help"

The circulation of 3D-printed samples ably demonstrated why using 3D prototypes are needed. All samples were touched, turned around and compared to other samples. Conversations with neighbors were started and continued even though the presentation was ongoing.

This case example indicates that prototyping and 3D printing can be used to open and increase communication even in an industry case in which it is not intuitively a clear choice.

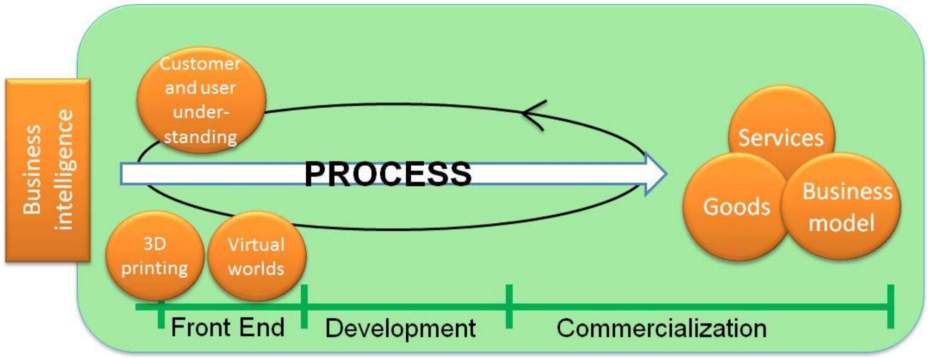

Figure 6. Three perspectives of rapid innovation practices fostering innovation speed.

IV. DISCUSSION

In the previous chapters, we described three perspectives on rapid innovation practices: (1) customer and user understanding, (2) distributed collaboration, and (3) prototyping abilities. We empirically studied the functionality of these perspectives in the context of our case company.

Fig. 6 below adjoins the aforementioned rapid innovation practices with the innovation context. We suggest that these rapid innovation practices increase innovation process speed.

The experiences from the customer and user understanding case study show that collaboration with customers is seen as an important part of the innovation process that supports previous studies [23], [24], [32], [77]. Moreover, the development of more customer (and user) participatory practices, not forgetting the importance of knowledge-sharing practices within the organization, is considered to foster and speed the innovation process.

We suggested that distributed working practices and the virtual world as a collaboration environment would form a rapid innovation practice contributing to innovation process speed. Parallel with the current state of research as well as our previous findings [2], our empirical case study indicates the emerging potential of virtual worlds to act as a platform for distributed ideation and innovation process activities. By enabling a successful distributed collaboration, virtual worlds might therefore enhance the innovation process speed.

We suggested that prototyping and 3D printing as a specific tool could enhance innovation process speed. Our case study illustrates that 3D printing will help to facilitate communication and understanding, which supports previous studies [11], [16]. Fewer misconceptions and less confusion will create an opportunity for a faster innovation process.

Added to the role of the aforementioned rapid innovation practices, we find it essential to discuss the role of speed or rapidity in the innovation process. For instance, the possible existing dichotomy between the quality and speed of innovation process decisions is left unanswered in this study. Meanwhile, the concept of innovation process speed might be diverged to sub-categories: for instance, the turn-around time of the entire innovation process and the reaction speed in different occurrences during the process represent different aspects of innovation speed. However, our case studies demonstrate that collaboration with different parties within the organization and with customers and users creates the ability to make the right decisions at the right time.

We consider our study as a baseline research approach. Therefore, several issues can be identified as further departures for research efforts. First, we consider the boundaries between each rapid innovation practice worth investigating. For instance, it is relevant to inquire about how distributed work technologies can support customer understanding and how prototyping abilities can be utilized in distributed work. Moreover, we call for other possible extensions of our list of three rapid innovation practices. Meanwhile, the mutual significance and the essence of each practice is a relevant object of research in our consideration.

Additionally, we call for the expansion of our research to cover other phases of innovation process added to the front end, which embraces the context of our current study. We call for research that targets rapid innovation practices contributing to specific outputs of the innovation process, including goods, services and business models.

REFERENCES

[1] Akroyd, C., Narayan, S., & Sridharan, V. (2009). The use of control systems in new product development innovation: advancing the 'help or hinder'debate. *The IUP Journal of Knowledge Management, 7*(5), 70-90.

[2] Alahuhta, P., Nordbäck, E., Sivunen, A & Surakka, T. (2014, forthcoming). Fostering Team Creativity in Virtual Worlds. *Journal of Virtual Worlds Research.*

[3] Amit, R., & Zott, C. (2001). Value creation in e-business. *Strategic management journal*, *22*(6-7), 493 520.

[4] Andriessen, J. E., & Vartiainen, M. (Eds.). (2006). *Mobile virtual work [electronic resource]: a new paradigm?*. Springer.

[5] Bhagwatwar, A., Massey, A., & Dennis, A. R. (2013). Creative Virtual Environments: Effect of Supraliminal Priming on Team Brainstorming. *2013 46th Hawaii International Conference on System Sciences*, 215-224. doi:10.1109/HICSS.2013.152

[6] Birnbaum-More, P. H. (1993). New product development time: A cross-national study. *Center for Innovation Management Studies*, Lehigh University, Bethlehem, PA,

[7] Björkstrand, R., Lallimo, J., Kanerva, J, *Socio-technical knowledge management in product design environment*, BIT Research Centre, Espoo, 2006

[8] Boland, R. J., Lyytinen, K., & Yoo, Y. (2007). Wakes of innovation in project networks: the case of digital 3-D representations in

architecture, engineering, and construction. *Organization Science*, *18*(4), 631-647.

[9] Bonner, J. M., Ruekert, R. W., & Walker Jr, O. C. (2002). Upper management control of new product development projects and project performance. *Journal of Product Innovation Management*, 19(3), 233-245.

[10] Bosch-Sijtsema, P. M., Fruchter, R., Vartiainen, M., & Ruohomäki, V. (2011). A framework to analyze knowledge work in distributed teams. *Group & Organization Management*, *36*(3), 275-307.

[11] Broek, J.J., Sleijffers, W., Horváth, I. & Lennings, A.F. (2000) Using Physical Models in Design. *Proceedings of CAID/CD'*

[12] Brown, S. L., & Eisenhardt, K. M. (1997). The art of continuous change: Linking complexity theory and time-paced evolution in relentlessly shifting organizations. *Administrative Science Quarterly*, , 1-34.

[13] Brown, T. (2008). Design thinking. *Harvard Business Review*, 86(6), 84.

[14] Buxton, W. 2007. Sketching user experiences: getting the design right and the right design. Morgan Kaufmann

[15] Carbonell, P., Rodríguez-Escudero, A. I., & Pujari, D. (2009). Customer Involvement in New Service Development: An Examination of Antecedents and Outcomes. *Journal of Product Innovation Management*, 26(5), 536-550.

[16] Carleton, T., & Cockayne, W. (2009). The power of prototypes in foresight engineering. Proceedings from the 17th International Conference of Engineering Design (ICED).Cooper, J. R. (1998). A multidimensional approach to the adoption of innovation. *Management Decision*, 36(8), 493-502.

[17] Cooper, R. G. (1988). The new product process: a decision guide for management. *Journal of Marketing Management*, 3(3), 238-255.

[18] Cooper, R. G. (1993). *Winning at new products – accelerating the products from idea to launch*. 2nd Ed., MA Addison-Wesley, Reading.

[19] Cooper, R. G. (2005). New Products—What Separates the Winners from the Losers and What Drives Success. The PDMA Handbook of New Product Development, , 3-28.

[20] Coviello, N. E., & Joseph, R. M. (2012). Creating Major Innovations with Customers: Insights from Small and Young Technology Firms. *Journal of Marketing*, 76(6), 87-104.

[21] Dwyer, L., & Mellor, R. (1991). Organizational environment, new product process activities, and project outcomes. Journal of Product Innovation Management, 8(1), 39-48.

[22] Edvardsson, B., Johnson, M. D., Gustafsson, A., & Strandvik, T. (2000). The effects of satisfaction and loyalty on profits and growth: products versus services. *Total Quality Management*, *11*(7), 917-927.

[23] Edvardsson, B., Kristensson, P., Magnusson, P., & Sundström, E. (2012). Customer integration within service development—A review of methods and an analysis of insitu and exsitu contributions. *Technovation*, *32*(7), 419-429.

[24] Edvardsson, B., Tronvoll, B., & Gruber, T. (2011). Expanding understanding of service exchange and value co-creation: a social construction approach. *Journal of the Academy of Marketing Science*, *39*(2), 327-339.

[25] Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review*, 14(4), 532-550.

[26] Ellwood, P., Grimshaw, P., & Pandza, K (2013). Innovation Speed-A Systematic Literature Review. *ISPIM Conference*, 17.-19.6.2013, Helsinki, Finland.

[27] Enkel, E., Gassmann, O., & Chesbrough, H. (2009). Open R&D and open innovation: exploring the phenomenon. *R&D Management*, *39*(4), 311-316.

[28] Eschenbächer, J., Seifert, M., & Thoben, K. D. (2009). Managing distributed innovation processes in virtual organizations by applying the collaborative network relationship analysis. In *Leveraging Knowledge for Innovation in Collaborative Networks* (pp. 13-22). Springer Berlin Heidelberg.

[29] Fuller, J., Muller, J., Hutter, K., Matzler, K., & Hautz, J. (2012). Virtual worlds as collaborative innovation and knowledge platform. *2012 45th Hawaii International Conference on System Sciences*, 1003–1012. doi:10.1109/HICSS.2012.636

[30] Gajendran, R. S., & Joshi, A. (2012). Innovation in globally distributed teams: The role of LMX, communication frequency, and member influence on team decisions. *Journal of Applied Psychology*, *97*(6), 1252.3

[31] Garcia, R., & Calantone, R. (2002). A critical look at technological innovation typology and innovativeness terminology: a literature review. *Journal of Product Innovation Management*, 19(2), 110-132.

[32] Gherardi, S. (2000). Practice-based theorizing on learning and knowing in organizations. *Organization*, 7(2), 211-223.

[33] Gibbert, M., Leibold, M., & Probst, G. (2002). Five styles of customer knowledge management, and how smart companies use them to create value. *European Management Journal* 20 (5), 459-469.

[34] Gibson, C. B. & Gibbs, J. L. (2006). Unpacking the concept of virtuality: The effects of geographic dispersion, electronic, dynamic structure, and national diversity on team innovation. *Administrative Science Quarterly*, *51*(3), 451-495.

[35] Goktan, A. B., & Miles, G. (2011). Innovation speed and radicalness: are they inversely related? *Management Decision*, 49(4), 533-547.

[36] Green, S. G., Gavin, M. B., & Aiman-Smith, L. (1995). Assessing a multidimensional measure of radical technological innovation. Engineering Management, IEEE Transactions on, 42(3), 203-214.

[37] Griffin, A. (1997). The effect of project and process characteristics on product development cycle time. *Journal of Marketing Research,* Feb/1997 , 24-35.

[38] Griffith, T. L., J. E. Sawyer, and M. A. Neale 2003 "Virtualness and knowledge in teams: Managing the love triangle of organizations, individuals, and information technology." *MIS Quarterly*, *27*(1), 265–287.

[39] Gruner, K. E., & Homburg, C. (2000). Does customer interaction enhance new product success? *Journal of Business Research*, 49(1), 1-14.

[40] Hertenstein, J., & Platt, M. (1998). A management accounting challenge: designing performance measures for industrial design and new product development teams. Unpublished Paper. Northeastern University, Boston,

[41] Houde, S. & Hill, C. (1997). What do Prototypes Prototype? *Handbook of Human Computer Interaction* 2nd edition, 367-381

[42] Kauppila, O. P., Rajala, R., & Jyrämä, A. (2011). Knowledge sharing through virtual teams across borders and boundaries. *Management Learning*, *42*(4), 395-418.

[43] Kessler, E. H., & Chakrabarti, A. K. (1996). Innovation speed: a conceptual model of context, antecedents, and outcomes. *Academy of Management Review*, , 1143-1191.

[44] Kesting, P., & Ulhøi, J. P. (2010). Employee-driven innovation: extending the license to foster innovation. Management Decision, 48(1), 65-84.

[45] Khurana, A., & Rosenthal, S. R. (1997). Integrating the fuzzy front end of new product development. *Sloan Management Review*, 38, 103-120.

[46] Khurana, A., & Rosenthal, S. R. (1998). Towards holistic "front ends" in new product development. *Journal of Product Innovation Management*, 15(1), 57-74.

[47] Kim, J., & Wilemon, D. (2002). Focusing the fuzzy front–end in new product development. *R&D Management*, 32(4), 269-279.

[48] Koen, P., Ajamian, G., Burkart, R., Clamen, A., Davidson, J., D'Amore, R., Johnson, A. (2001). Providing clarity and a common language to the" fuzzy front end". *Research-Technology Management*, 44(2), 46-55.

[49] Kohler, T., Fueller, J., Matzler, K., & Stieger, D. (2011a). Co-creation in virtual worlds: The design of the user experience. *MIS quarterly*, *35*(3), 773–788.

[50] Kohler, T., Fueller, J., Stieger, D., & Matzler, K. (2011b). Avatar-based innovation: Consequences of the virtual co-creation experience. *Computers in Human Behavior*, *27*(1), 160–168. doi:10.1016/j.chb.2010.07.019

[51] Kohler, T., Matzler, K., & Füller, J. (2009). Avatar-based innovation: Using virtual worlds for real-world innovation. *Technovation*, *29*(6-7), 395–407. doi:10.1016/j.technovation.2008.11.004

[52] Kristiansen, P., Hansen, P. H. K., & Møller Nielsen, L. (2009). Articulation of tacit and complex knowledge. Learning and

Innovation in Value Added Networks, *Proceedings of the 13th IFIP*, 5, 77-86.

[53] Kurtzberg, T. R. & Amabile, T.M. (2001). From Guilford to creative synergy: Opening the black box of team-level creativity. *Creativity Research Journal*, *13*(3-4), 285-294.

[54] Kvan, T. (2000). Collaborative design: what is it?. *Automation in construction*, *9*(4), 409-415.

[55] Lakhani, K. R., & Panetta, J. A. (2007). The principles of distributed innovation. *Innovations*, *2*(3), 97-112.

[56] Larach, D., & Cabra, J. F. (2010). Creative problem solving in Second Life: an action research study. *Creativity and Innovation Management*, *19*(2), 167-179.

[57] Lempiälä, T. 2011. "Entering the back stage of innovation : tensions between the collaborative praxis of idea development and its formal staging in organisations", Helsinki, Aalto Print.

[58] Lettl, C. (2007). User involvement competence for radical innovation. *Journal of Engineering and Technology Management*, 24(1), 53-75.

[59] Loch, C. (2000). Tailoring product development to strategy: case of a European technology manufacturer. European Management Journal, 18(3), 246-258.

[60] Martins, L. L., & Shalley, C. E. (2011). Creativity in virtual work: effects of demographic differences. *Small Group Research*, 42(5), 536-561.

[61] Maturana, H. R., & Varela, F. J. (1987). *The tree of knowledge: The biological roots of human understanding*. New Science Library / Shambhala Publications.

[62] McGuinness, N. W., & Conway, H. A. (1989). Managing the search for new product concepts: a strategic approach. *R&D Management*, 19(4), 297-308.

[63] Menon, A., Chowdhury, J., & Lukas, B. A. (2002). Antecedents and outcomes of new product development speed: an interdisciplinary conceptual framework.*Industrial Marketing Management*, *31*(4), 317-328.

[64] Morris, M., Schindehutte, M., & Allen, J. (2005). The entrepreneur's business model: toward a unified perspective. *Journal of business research*, *58*(6), 726-735.

[65] Nijssen, E. J., Arbouw, A. R. L., & Commandeur, H. R. (1995). Accelerating new product development: A preliminary empirical test of a hierarchy of implementation. *Journal of Product Innovation Management*, 12(2), 99-109.

[66] Nobelius, D., & Trygg, L. (2002). Stop chasing the Front End process--management of the early phases in product development projects. *International Journal of Project Management*, 20(5), 331-340.

[67] Nordlund, H. (2009). "Constructing customer understanding in front end of innovation". University of Tampere, Tampere.

[68] OECD (1991). "Basic science and technology statistics". Organization for Economic Cooperation and Development, Paris.

[69] Olson, P. D., & Bokor, D. W. (1995). Strategy process-content interaction: Effects on growth performance in small, start-up firms. *Journal of Small Business Management*, 33, 34-34.

[70] Orlikowski, W. J. (2002). Knowing in practice: Enacting a collective capability in distributed organizing. *Organization Science*, 13(3), 249-273.

[71] Osterwalder, A., Pigneur, Y., & Tucci, C. L. (2005). Clarifying business models: Origins, present, and future of the concept. *Communications of the Association for Information Systems*, 16(1), 1-25.

[72] Parry, M. E., Song, M., De Weerd-Nederhof, P. C., & Visscher, K. (2009). The impact of NPD strategy, product strategy, and NPD processes on perceived cycle time. *Journal of Product Innovation Management*, 26(6), 627-639.

[73] Partanen, J. P.,Tuomi, J. & Vihtonen, L. (2010) "Toolless Layer-Wise Production Methods: Adaptable and Fast Way to Customer," International Conference on Additive Technologies, iCAT 2010, Nova Gorica, Slovernia, 22-24rd September 2010, *Annals of DAAAM for 2010 & Proceedings of the 21st International DAAAM Symposium*, 20-23rd October 2010, Zadar, Croatia, ISSN 1726-9679, ISBN 978-3-901509-73-5, Katalinic, B. (Ed.), pp. 1587-1588, DAAAM International, Vienna (2010).

[74] Paulus, P. B. & Huei-Chuan, Y. (2000). Idea generation in groups: A basis for creativity in organizations. *Organizational behavior and human decision processes, 82*(1), 76-87.

[75] Peters, L. M., & Manz, C. C. (2007). Identifying antecedents of virtual team collaboration. *Team Performance Management*, *13*(3/4), 117-129.

[76] Poskela, J., Dietrich, P., Berg, P., Artto, K. A., & Lehtonen, T. (2005). Integration of strategic level and operative level front-end innovation activities. In Technology management: A unifying discipline for melting the boundaries (pp. 197-211). IEEE.

[77] Prahalad, C. K., & Ramaswamy, V. (2000). Co-opting customer competence. *Harvard Business Review*, 78(1), 79-90.

[78] Prahalad, C. K., & Ramaswamy, V. (2004). Co-creation experiences: The next practice in value creation. *Journal of interactive marketing*, *18*(3), 5-14.

[79] Reckwitz, A. (2002). Toward a theory of social practices: a development in culturalist theorizing. *European Journal of Social Theory*, 5(2), 243-263.

[80] Ringo, Tim. (2007). IBM explores new frontiers in collaborative innovation. *Research Technology Management*, *50*(5), 6–7.

[81] Rosenman, M. A., Smith, G., Maher, M. L., Ding, L., & Marchant, D. (2007). Multidisciplinary collaborative design in virtual environments. *Automation in Construction*, *16*(1), 37-44.

[82] Segarra, G. (1999). The advanced information technology innovation roadmap. *Computers in Industry*, *40*(2), 185-195.

[83] Slater, S. F., & Narver, J. C. (1995). Market orientation and the learning organization. *The Journal of Marketing*, 59, 63-74.

[84] Slaughter, R. (1995). The foresight principle: Cultural recovery in the 21st century Praeger Westport, CT.

[85] Smith, P.G. and Reinertsen, D.G. (1998). Developing Products in Half the Time: New Rules, New Tools (2nd ed.), New York: John Wiley & Sons.

[86] Snowden, D. J., & Boone, M. E. (2007). A leader's framework for decision making. *Harvard Business Review*, 85(11), 68.

[87] Stucker, Brent (2012). National Research Council. *Frontiers of Engineering 2011: Reports on Leading-Edge Engineering from the 2011 Symposium*. Washington, DC: The National Academies Press, 2012. 5-14

[88] Thatcher, S. M. B., & Brown, S. A. (2010). Individual creativity in teams: The importance of communication media mix. *Decision Support Systems*, 49(3), 290-300

[89] Tikkanen, H., Lamberg, J. A., Parvinen, P., & Kallunki, J. P. (2005). Managerial cognition, action and the business model of the firm. *Management Decision*, 43(6), 789-809.

[90] Tsoukas, H., & Shepherd, J. (2004). Organisations and the future, from forecasting to foresight. Managing the Future.Foresight in the Knowledge Economy.Oxford: Blackwell Publishing, 1-17.

[91] Tuomi, J., Björkstrand, R., Surakka, T. Suutala, K., Patosalmi, J., Korhonen, M, Tuotemallien käyttö palveluprosesseissa, TAI tutkimuslaitos, Espoo, 2003.

[92] Ullman, D. G. (2003) The mechanical design process. McGraw-Hill, New-York

[93] Ulrich, K. T. & Eppinger, S.D. (2003). Product Design and Development. McGraw-Hill, New-York

[94] Vasconcelos, V., & Campos, P. (2010). Distributed informal information systems for innovation: An empirical study of the role of social networks. In *ENTERprise Information Systems* (pp. 208-217). Springer Berlin Heidelberg.

[95] Von Hippel, E. (1994). "Sticky information" and the locus of problem solving: implications for innovation. *Management science*, *40*(4), 429-439.

[96] Vosinakis, S., & Koutsabasis, P. (2013). Interaction design studio learning in virtual worlds. *Virtual Reality*, *17*(1), 59–75. doi:10.1007/s10055-013-0221-1

[97] Wheelwright, S. C., & Clark, K. B. (1992). Revolutionizing product development: quantum leaps in speed, efficiency, and quality Free Pr.

[98] Wohlers, Terry. 2012. "Wohlers report 2012, Additive manufacturing and 3D-printing, State of the Industry"

[99] Yang, M. C. (2005). A Study of prototypes, design activity, and design outcome. *Design Studies* Vol 26, 649-699.

[100] Yee, N. & Bailenson, J. (2007). The Proteus effect: The effect of transformed self-representation on behavior. *Human Communication Research*, 33(3), 271-290.

[101] Yin, R.K. (1994). “Case study research: design and methods”, Sage Publications.

[102] Zhang, Q., & Doll, W. J. (2001). The fuzzy front end and success of new product development: a causal model. *European Journal of Innovation Management*, 4(2), 95-112.