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Dancing with Creativity: Changes in Conception in Design Thinking within Product Innovation Projects

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Abstract: The research presented in this article investigates and discusses the changes in conception throughout twenty-three product innovation projects. Changes in conception in the thinking of the designer that leads to novel design concepts have been investigated mainly in situ through methods such as protocol analysis. However, scholars emphasized that changes in conception happen over longer periods. For this reason, the research examined the changes in conception throughout a nine-month product innovation project. The changes in conception were investigated by identifying the main word-groups used to describe the design concept at different project stages and examining when the word-groups changed over the project period. Design teams produced the reports at specific stages in the project. This consistency allowed comparing twenty-three projects over three consecutive years. The analysis revealed specific conditions that facilitate novel conceptual changes necessary to create an innovative product design concept.

Keywords: reframing; design thinking; engineering design; prototyping

1. Introduction

When do designers have creative leaps that result in new design concepts has been a long interest in design. Many scholars investigated and developed practices and exercises which facilitate creative leaps (e.g., Adams, 2001; Arnold, 1962a, 1962b; Arnold & Arnold, 2016; Dorst, 2015; McKim, 1980; Schön, 1983, 1984). For example, research in design thinking examined the cognitive strategies of problem-solving revealing approaches such as problem and solution framing (e.g., Dorst & Cross, 2001; Lawson, 1979; Schön, 1983, 1984; Valkenburg & Dorst, 1998). These studies examined the thinking and activities through direct observations in situ utilizing methods such as protocol analysis. Protocol analysis is a valuable but highly specific research technique that captures a few aspects of design thinking in detail (Cross, 2001). However, it is failing to encompass many of the broader realities of design (Cross, 2001). A particular broader reality is the emergence and evolution of creative

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leaps in design throughout a longer period. Psychologist and creativity scholars have long emphasized that creative leaps include a period of incubation of conscious and unconscious processes (e.g., Koestler, 1964; Wallas, 1926). For example, Arnold (1959) described that creativity in design requires a questioning attitude and obsessive observations to recognize patterns in the environment relevant to the solution. These patterns need to be combined and recombined through mental processes of association to create novel or original ideas and require prediction to select the most promising ones (Arnold, 1959). In situ observations examine such activities and thinking of designers in detail. However, they do not observe how, e.g., conceptions in observation relate to conceptualizing the design of the functional product system in a later phase. Investigating creative leaps throughout an entire product innovation project allows identifying the interrelations of changes in the design concept. Therefore, the research presented in this article examines the changes in the design concepts of twenty-three design teams throughout a nine-month program. The study investigates when design teams create and explore changes in the concept of the design within product innovation projects.

2. Background

The challenge for design teams in creating innovative solutions is to produce a novel and tangible outcome that is meaningful, manufacturable, and marketable. Several scholars developed design practices that aim to fulfill people's needs, while generating feasible, manufacturable, and marketable product (e.g., Arnold, 1959; McKim, 1959; Srinivasan, Lovejoy, & Beach, 1997). This creative, experiential, and human-centered design approach has been cultivated and advanced in design firms such as IDEO (e.g., Buchenau & Fulton Suri, 2000; Fulton Suri, 2003; Gilmore et al., 1999; Hargadon & Sutton, 2000; Leonard & Rayport, 1997; Moll-Carrillo, Salomon, Marsh, Fulton Suri, & Spreenbergh, 1995; Sutton & Hargadon, 1996). These specific design practices became widespread under the term Design Thinking (e.g., Brown, 2008; Leifer & Steinert, 2011).

2.1 Design Thinking as an innovation practice

Innovative design requires (1) novelty through creativity and (2) meaningfulness for people, feasibility and manufacturability of the technology, and salability of the product system through a sustainable business model.

Scholars investigated and developed several (1) creative practices in design (e.g., Arnold, 1962a, 1962b; Arnold & Arnold, 2016; McKim, 1980; Schön, 1983, 1984). Arnold (1959, 1962a, 1962b) outlined practice and exercises for developing the creative skills and abilities in design. He describes the attitudes of questioning, observing, associating, and predicting in combination with the mental attributes of openness to experience, fluency and flexibility, and originality (1962a, 1962b). These are based on early creativity research by Guilford (1950, 1957) and Rogers (1954). This educational approach by Arnold (1962a) facilitates the development of the inherent creative potential of designers. McKim (1972,

1980) expanded this practice through visual thinking practices to enable seeing, imagining, and idea sketching, while Adam (2001) developed strategies in design to overcome blocks to creativity. Other scholars investigated the problem-solving strategies. For example, Schön (1983, 1984) examined and outlined the reflective practices of framing, moving, and reflecting to create different design concepts to solve complex problems. Based on Schön's (1983) work, Dorst and colleagues expanded the reframing practices (Dorst, 2015; Dorst & Cross, 2001; Valkenburg & Dorst, 1998). These mental activities, such as association and visual imagination, are conducive to creativity. Specific practices and techniques such as brainstorming, Morphological analysis, visualization, and prototyping activities assist these mental activities (e.g., Adams, 2001; Arnold, 1962b; McKim, 1980).

Furthermore, product innovation requires (2) meaningfulness, feasibility and manufacturability, and salability. The above described creative design practices were advanced through practices such as need-finding that aim to fulfill human needs (Faste, 1987; McKim, 1959). This practice enables the design of meaningful concepts for people. Srinivasan et al. (1997) developed practices to generate manufacturable and marketable products based on design activities such as prototyping. These specific design activities aim to enable the (1) creative mental activities (thinking) and the (2) development of human-centric, technologically feasible, and business viable design concepts (outcome). Figure 1 illustrates this interrelation between design outcomes and design activities and thinking.

Figure 1 *Illustrates how a design prompt or design concept turns into action, learning, and new outcome. Each cycle aims to generate changes in the design concept. Each conceptual change results from the learning from previous concepts in combination with new learnings based on the design activities.*

Figure 1 illustrates the design cycle as a step process. However, in reality, activities occur simultaneously and represent attitudes of the designer's mind and not step-by-step processes (e.g., Arnold, 1959; Black, Bayley, Burns, Kuuluvainen, & Stoddard, 1994). In the iterative design cycles, creative leaps based on conceptual change in the thinking of the designers are essential to produce a novel design concept. As discussed above, specific creative design activities facilitate changes in conception in design. By facilitating design teams in these specific practices, they experience and learn Design Thinking as an innovation practice while attempting to create innovative products.

2.2 Facilitating Design Thinking

Several scholars developed project-based and experiential learning approaches to facilitate

the learning of the creative and human-centered engineering design practice to develop the necessary skills and abilities (Dym, Agogino, Eris, Frey, & Leifer, 2005; Leifer, 1998; Wilde, Faste, & Roth, 1994). As illustrated in Figure 1, this experiential learning follows a learning cycle of design-build-test in a collaborative environment (Leifer & Steinert, 2011). Formal, informal, and experiential knowledge creation facilitates the learning process of the design practice (Eris & Leifer, 2003). Figure 2 illustrates the three learning loops that enable the design team in their experiential learning and innovation challenges.

Figure 2 Illustrates the three learning loops of formal, procedural, and experiential knowledge in the education of Design Thinking teams. Based on Eris & Leifer (2003) and Leifer & Steinert (2011).

In these learning loops, the coaches are the learning mediators for the design teams. They provide formal knowledge such as expert knowledge in the form of conceptual models and codified specific design practices and informal knowledge such as procedural support. The coaches enable the design teams in their design activities and experiential learning. At different points of the innovation project, specific Design Missions support in the facilitation of the design team practices of exploring people's needs, functionality, manufacturability, and marketability. Design Missions aim to enable teams to explore different areas of the design space and encourage them to tackle different design challenges (Bushnell, Steber, Matta, Cutkosky, & Leifer, 2013). Figure 3 shows this facilitation, and Table 1 outlines the Design Missions.

Figure 3 shows the facilitation of the thinking and activities of the design teams through specific Design Missions.

Table 1 *Design Missions in the Design Innovation course ME310 (Domingo et al., 2020)*

Design Mission	Challenge	Description
Paper bike (not included in the analysis)	Learning of the design cycle	The paper bike challenge is an initial exercise to provide the student teams with the experience of how designers frame, act, reflect, and reframe to create a design solution for the competitive and fun pre-determined game.
Needfinding (NF)	Identify people's needs	Needfinding reveals needs and explores the context of the person/people for whom to design for by observation, intervening, engaging, and ethnographic interviews.
Benchmarking (BM)	Evaluation of existing solutions	Benchmarking is a physical activity to learn what existing solutions solve the problem and what they do poorly.
Critical Experience (CEP)	Evaluation of experience of users	The critical experience prototype involves creating an experience that answers a particular design question (why) about people's behavior in relation to the aspect of a design. The CEP often utilizes the Wizard of Oz prototyping approach.
Critical Function (CFP)	Evaluation of functionality of the design	The critical function prototype is a physical artifact with the focus on how a design function is needed to deliver the experience.
Dark Horse (DH)	Exploration of risky ideas after design vision has established	Design teams intentionally explore a concept, technology, or idea that would have otherwise not been seriously considered as it is considered unrealistic, too risky, radical, or challenging to implement (Bushnell et al., 2013). It aims to keep the ambiguity high by keeping the conceptual solution space from narrowing down too quickly.
Funky (Funk)	Exploration of a low-fidelity physical system	The funky systems prototype is bringing together parts into a physical system in a manner without making a costly commitment. It is a rapidly assembled concept prototype that allows evaluating and testing of the physical system.
Functional (Func)	Development of product system	The functional systems prototype helps to decide what the system should encompass, the scope, and the joint vision of the design project. It links the human need with major technical issues.
Part X	Development of the critical part	Part X aims to go from a late-stage prototype to a final prototype by getting a vital part of the system done early enough to start undergoing refinements.
Penultimate	Finalizing design concept and story	Penultimate aims to increase the chances to produce a polished final product for the final deadline by "freezing" the design concept.
Final (EXPE)	Presenting the final concept	The EXPE includes presenting the final design to the industry partner.

For each of the different Design Missions, as outlined in Table 1, design teams captured the created design concepts in “Design Mission reports.” These reports are the data basis of this study. The examination of the reports allowed identifying changes in the design concepts throughout the entire product innovation project.

3. Methodology

The study was conducted in the Design Innovation course ME310. ME310 stands for Mechanical Engineering with class number 310. Jim Adams established the course in 1967. Adams started the course as he was unhappy with the no hands-on engineering curriculum (Carleton, 2019). Today, ME310 is a three-quarter engineering design course, in which graduate students need to design and develop breakthrough design concepts for industry partners. They work in collaboration with a student team from other universities, which are located in different countries throughout the globe (Larsson et al., 2003).

Students are facing real-world design challenges sponsored by a corporate partner, which in the past included companies such as SAAB, Microsoft, GM, Volvo, Huawei, AUDI, and Siemens. These design challenges are similar to real-world design projects in the industry as insights are ambiguous, the goals are not clear, and tasks are open-ended (Jung, 2011). The product development is usually performed by three to four students at each university. Teams are self-organized and are supported by Professors and Teaching Assistants of three alumni who have completed the course in one of the previous years (Jung, 2011). The assigned remote partner team is supported by a similar staff set up, although the curriculum and design focus can vary from university to university. The context in which student teams are embedded in is shown in Figure 4. This case allows examining the change in conception as design teams are required to come up with a novel design that fulfills a need or solves a problem within real industry partner projects.

Figure 4 Shows the wider context in which the graduate student design teams are embedded. It illustrates the support and collaborative environment of ME310.

3.1 Study design

The research investigates the creative leaps in the thinking of the design teams indirectly by examining the changes in the design concepts described in the Design Mission reports, as illustrated in Figure 5.

Figure 5 Illustrates a simplified representation of the change in the design concept. Each conceptual change is facilitated by the learning from past design activities and/or triggered by a specific design practice that leads to new learnings. The model is based on the single and double-loop learning model that incorporates a change in mental models (thinking) or changes in activities (action) to produce a change in outcome (design concept) (Argyris, 1976, 2002; Argyris & Schön, 1989, 1992)

These changes are triggered through external stimuli such as conversations and produced through internal mental activities such as imagination. For the design teams to explore and create novel design concepts, the design teams have to recognize the information and decide to act on it consciously. Each Design Mission report describes the consciously explored and created design concepts. The study was designed to examine the reports of each Design Mission through a Computer-Aided Text Analysis (CATA), which allowed investigating the changes in conception indirectly throughout the innovation project.

3.2 Sample and secondary data

The study incorporates a sample size of twenty-three design projects representing twenty-three teams of three consecutive years. The study included a total of two hundred thirty reports. The three years were chosen as all relevant reports were available. Design projects from other years were not included due to one or more missing reports.

3.3 Data analysis

The analysis was designed to examine conceptual changes throughout the innovation project. Table 2 shows three design concept examples resulting from three different Design Missions. Each design concept is represented as a physical design (pictures in Table 2 Examples of Design Concepts and two types of abstraction (text sample and word-groups)) and the descriptions in the Design Mission report ("Text in the report" in Table 2 Examples of Design Concepts and two types of abstraction (text sample and word-groups)).

Table 2 Examples of Design Concepts and two types of abstraction (text sample and word-groups)

Design Mission	Critical Experience Prototype (CEP)	Critical Function Prototype (CFP)	Dark Horse Prototype (DH)
Design Concept
Text in the report	“[...] to create furniture forms , we placed the frame and pellets into vacuum-formable bags and had users sit or otherwise interact with the forms to create personalized vacuum-formed prototypes. [...]”	“[...] for our CFP, we explored the concept of artificial elegance as a means of adding perceived value to ‘ company name ’ furniture. [...] We improved the aesthetic of a ‘ table name ’ table by [...].”	“[...] while successful, the assembly process company name has developed could be improved greatly. The introduction of a universal fastener , the metal snap , could revolutionize the very definition of assembly . Snaps could mark the end of the [...] assembly process that accompanies the majority of Company name’s products.”
Word-groups	Furniture, Create, Form, Pellets, and Vacuum	Table, Improve, Elegance, ‘Company name,’ and ‘Table name’	Snap, Assembly, ‘Company name,’ Metal, Process, Fastener, Improve, and Magnet, Prototype

The Design Mission reports were analyzed through a CATA. Firstly, the reports were analyzed independently to identify the main *word-groups* that represent the design concept, as exemplified in Table 2. Representing the design concept through key word-groups identifies the main aspects of the design concept and, at the same time, reduces the information and meaning. This reduction is a limitation of the study. However, it allowed examining conceptual changes through the CATA.

Secondly, changes in word-groups from one design concept to another allowed the identification of the conceptual changes. For example, the design concept in the Design Mission CEP is a furniture that is created easily from pellets and vacuum-formable bags, as outlined in Table 2. The word-groups representing this design concept are Furniture, Create, Form, Pellets, and Vacuum. The next Design Mission of CFP explores the elegance and aesthetics of a table to improve the specific table of the company. The word-groups representing this design concept are Table, Improve, Elegance, ‘Company name,’ and ‘Table name.’ The difference in word-groups indicates that the team had a change in conception and explored a different concept in the CFP Design Mission in comparison to the previous

concept in the Design Mission CEP. Table 3 outlines the several steps of this data analysis.

Table 3 Data analysis process to identify conceptual changes throughout the innovation process

Steps	Description
1. Determining the preliminary word groups	<p>NVivo performed an automatic grouping of words sharing the same word stem.</p> <ul style="list-style-type: none"> • Nouns, adjectives & verbs sharing same word stem • Word length > 2 letters • Numbers (“111”) and self-defined stop words (“http”) not considered
2. Determining uniformed word-groups	<p>Comparison of word-groups across all reports, teams, and years to determine uniformed word-groups.</p> <ul style="list-style-type: none"> • Visual thesaurus was used to determine the related word-groups
3. Normalizing word-groups	<p>The Weighted Percentage (WP) was calculated (number of the words of a word-group relative to the total number of words in this report).</p>
4. Determining key word-groups	<p>The top five word-groups by WP per report were identified. These word-groups represent the main aspects of the design concept.</p> <ul style="list-style-type: none"> • A word-group is considered in the top five if its WP is among the five highest in at least one Design Mission report. • When two or more word-groups share the 5th rank due to the same WP, they were all included in the analysis. • The top five word-groups from each report were included in the analysis of all reports.
5. Conceptual changes	<p>Conceptual changes are the top five word-groups that change from one Design Mission report to another Design Mission report</p> <ul style="list-style-type: none"> • Conceptual changes are presented in percentage (%)
6. Novel conceptual changes	<p>The percentage of novel conceptual changes is identified in each Design Mission as follows: $\frac{\text{Novel top five word-groups}}{\text{Total top five word-groups}}$</p> <ul style="list-style-type: none"> • Novel top five word-groups do not occur in the previous Design Missions reports • Results presented in Figure 6
7. Reemerging conceptual changes	<p>The percentage of reemerging conceptual changes is identified in each Design Mission as follows: $\frac{\text{Repeating top five word-groups}}{\text{Total top five word-groups}}$</p> <ul style="list-style-type: none"> • The reemerging top five word-groups do not occur in the previous Design Mission report and occur in one of the Design Mission reports before the previous one. • The previous Design Mission report is excluded to identify the conceptual change and not repeating of same/similar concepts • Results presented in Figure 7

8. All conceptual changes	<p>The percentage of all conceptual changes is identified in each Design Mission as follows: $\frac{\text{All top five word-groups representing a conceptual change}}{\text{Total top five word-groups}}$</p> <ul style="list-style-type: none"> • All top (novel and reemerging) five word-groups that do not occur in the top five word-groups of the previous Design Mission report and might occur in the top five word-groups of the Design Missions report before the previous one • Results presented in Figure 8
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4. Findings

The CATA identified (1) novel conceptual change, (2) reemerging conceptual change, and (3) all conceptual changes throughout the product innovation project.

4.1 Novel conceptual changes in the design

The result of the analysis of the novel conceptual changes is illustrated in Figure 6 Shows the average of novel conceptual changes in all twenty-three design projects. All word-groups in the Needfinding Design Mission are novel (shown as 100%) as there is no previous Design Mission.. Figure 6 shows the average of the novel conceptual changes of all twenty-three projects.

Figure 6 Shows the average of **novel conceptual changes** in all twenty-three design projects. All word-groups in the Needfinding Design Mission are novel (shown as 100%) as there is no previous Design Mission.

Figure 6 indicates that in the first Design Missions of Needfinding (NF), Benchmarking (BM), Critical Experience Prototype (CEP), and Critical Function Prototype (CFP) design teams explore several novel concepts. These missions include identifying people's needs and their critical experience to define the innovation opportunity. It is an open exploration to define the design vision.

Figure 6 reveals that the Dark Horse and Part X Design Mission is facilitating novel conceptual changes. This finding shows that design teams explore novel concepts when pushed by the Dark Horse into exploring very risky, radical, or challenging ideas. The increase in Part X in Figure 6 indicates that the pressure of finalizing the product concepts facilitated the exploration of novel conceptual changes by the design teams.

4.2 Reemerging conceptual change in the design

The result of the analysis of reemerging conceptual change is illustrated in Figure 7. The figure shows the average of reemerging conceptual changes in all twenty-three design projects.

Figure 7 Shows the average of **reemerging conceptual changes** in all twenty-three design projects. The analysis identifies the reemerging change by comparing a “Design Mission Z” with the “Design Mission X” that occurs before the predecessor of the “Design Mission Z.” As a result, the first two Design Missions of Needfinding and Benchmarking have the value zero percent (0%).

Figure 7 shows that design teams reconsider previously explored concepts throughout the design project. Design teams reconsider previously explored concepts in particular in the Dark Horse, Funky, and Functional Design Mission. In these Design Missions, teams explore design solutions of previously identified opportunities, problems, and needs of people.

Interestingly, the Penultimate Design Mission reconsiders a large amount of previously

considered design concepts. This result occurs as the design teams reflect on the entire project to convey the learnings into a story to communicate the final design concept. Storytelling is essential to communicate the design concept's purpose, meaning, and value successfully by outlining the identified needs of people or problems that the design concepts fulfill or solves.

4.3 All conceptual changes in the design

The result of the analysis of all conceptual changes is illustrated in Figure 8. The figure shows the average of all conceptual changes in all twenty-three projects. Figure 8 illustrates that conceptual changes in the design are not a single or isolated activity of a creative phase that is followed by an implementation phase. Concept changes are interlinked and emerge through every iteration of a design cycle. It also shows that design teams, on average, never abandon all concepts and start from new.

Figure 8 Shows the average of **all conceptual changes** in all 23 design projects. All word-groups in the Needfinding Design Mission are novel (shown as 100%) as there is no previous Design Mission.

5. Discussion

In overall, the findings revealed that design teams explore novel concepts in the (I) early phases of a design project, (II) when exploring risky or radical ideas, and (III) before they have to finalize the design concept. The findings revealed that (IV) conceptual changes intertwine throughout the entire innovation project. They are not isolated activities of creativity followed by implementation. The last main finding was that (V) reflecting the entire project allows creating a story to communicate the final design concept. The next paragraphs discuss each main finding in more detail.

5.1 Explore the problem space by questioning the challenge

Arnold (1962a, 1962b) described two essential aspects when creating innovation in design. These are a questioning attitude in combination with thorough observation, and the challenge should be defined as broadly as possible to allow many possibilities. The findings in this study indicate that design teams firstly explore novel concepts in the early phases of the innovation project and, secondly, reconsider these conceptions when exploring solutions. These findings show that design teams utilize the early learnings and conceptions when creating novel solutions. Without these experiences of exploring novel design concepts, teams would not be able to reconsider and recombine these prior learnings. If teams were not able to explore novel concepts in the early phases, they would not have the same amount of novel conceptions to utilize to create novel solution concepts. In ME310, coaches expect and support the design teams in the exploration of the problem space by questioning the given challenge and discovering real-world problems and needs of people. Einstein & Infeld (1967) expressed this questioning attitude as follows:

“The formation of a problem is often more essential than its solution, which may be merely a matter of mathematics or experimental skill. To raise new questions, new possibilities, to regard old questions from a new angle, requires creative imagination and marks real advance in science.” (Einstein & Infeld, 1967)

The same applies when designing innovative products as otherwise, the design activities become merely the execution of a problem-solving task. Design teams reconsider and explore previous concepts during the exploration of solutions. Previously identified and defined conceptions of opportunities, problems, and people’s needs are part of the exploration of creating an innovative design concept. An essential condition for exploring the problem space is both the permission and expectation to question and broaden the given challenge through exploring real-world conditions.

5.2 Bet on the Dark Horse

Another interesting finding was the occurrence of conceptual changes through the Dark Horse Design Mission. This mission challenges teams to explore novel concepts after the formation of the design vision. The Dark Horse was created by Prof. Mark Cutkosky in 1999 to explicitly investigate the unlikely or unconsidered ideas to “colonize” the Design Space

(Bushnell et al., 2013). Design teams expressed the experience of the Dark Horse Design Mission as follows:

“The psychology of releasing the expectations while simultaneously pressuring teams to do the impossible pays off in nearly every project. This is even more significant because it occurs after the teams have already developed notions of what the product’s potential value may be.” (Bushnell et al., 2013)

The Dark Horse is a design practice that pushes design teams to explore the perceived impossible. The conditions of psychological safety and pressure to be able to explore risky ideas enables design teams to explore novel design concepts. Bushnell et al. (2013) outline several Dark Horse case studies that demonstrate the results. The Dark Horse Design Mission can facilitate conceptual changes beyond the obvious ideas, first solution, or blocks such as over-motivation as described by Adams (2001).

5.3 Last-Minute Conceptual Changes

The occurrence of novel conceptual changes in the Part X Design Mission is an interesting finding as it is the last phase in which design teams can explore novel concepts. Team members described that the psychological sensation of the feeling of pressure to finalize the design concept pushed them into exploring novel concepts. Last-minute novel conceptual changes occur under conditions such as the designed solution does not meet the expectation or design teams receive essential insights that need to be incorporated in the design. The finding indicates that time pressure and expectation drive conceptual changes in the design in last-minute situations.

5.4 Hunter-Gatherer

The findings revealed that conceptual changes intertwine throughout the entire innovation project. Design teams utilize learnings and conceptions from previous design cycles in later cycles. This phenomenon has been described by Steinert & Leifer (2012) as a Hunter-Gatherer Metaphor, as illustrated in Figure 9. With each design cycle, design teams make a new conceptual discovery that changes the design concept into a new direction. It requires exploring new directions (concepts) and change direction (act on the change in conception) with each learning. This creative practice requires both the mindset and environment of permission (psychological freedom) and expectation (motivation) to explore and create “the really big idea.”

Figure 9 Illustrates the Hunter-Gatherer Metaphor. The metaphor emphasizes that in education and businesses, there is a need to permit and facilitate people to go hunting to enable innovation (Steinert & Leifer, 2012).

The following questions and questioning attitude enable the mindset for hunting breakthrough ideas. Firstly, the question of *"why are people doing what they are doing and what is missing in their lives?"* allows exploring unmet human needs. This step follows by asking, *"what are we going to do to fulfill these needs?"* This question allows defining interesting directions to explore them to create a change in conception. *"How are we going to do it?"* enables exploring the concept. Reflecting on *"what have we learned?"* enables externalizing the experience into a concept and new direction. It is a "dance" that requires creativity to explore interesting directions in the design space by creating changes in conception and act on it.

5.5 Storytelling as part of the final design

Reflections and reconsiderations of several conceptions enable designers to tell a meaningful story about and through their design. This storytelling is essential in communicating the purpose, the why of the design. Why is this design useful? Why does it meet a need or solves a problem? Why was it designed this way and not that way? These Why-questions of the design make the conceptions explicit and provide meaning when communicating the final design concept to an audience. Reflection and storytelling reveal the underlying conceptions and allows communicating the meaning of the design.

6. Conclusion

The research presented in this paper indicated the importance of permission (psychological freedom) and challenge (motivation) to create changes in conception in design. In science,

Posner, Strike, Hewson, & Gertzog (1982) expressed four main conditions that lead to conceptual changes. These are dissatisfaction with existing conceptions, a new conception is intelligible, a new conception appears initially plausible, and a new conception suggests the possibility of a new area of inquiry. In design, the conditions for changes in conceptions are a questioning and observation attitude to explore real-world conditions, proactive exploration through impulse and motivation, and permission by betting on the Dark Horse, and reactive exploration of last-minute conceptual changes. These interlinked novel conceptions produce the innovative product design concept.

Design education programs in engineering, architecture, business, and other design-related practices that aim to facilitate experiential learning in Design Thinking and the generation of creative design concepts can incorporate the outlined practices that facilitate changes in conception. Enabling these creative design practices requires cultivating the coaching practices that facilitate psychological safety and freedom and encouraging design teams to explore new directions. The coaching includes expecting innovation (motivation), enabling design teams to explore and hunt (psychological freedom) and assist in the design practice (Design Missions). The practices and conditions facilitate the design teams in their dance with creativity. However, there is no guarantee of innovation. The dance with creativity in Design Thinking increases the chance of creating a novel product design concept that is meaningful, manufacturable, and marketable.

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