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Exploring Management of the Fuzzy Front End of Innovation in a Product Driven Startup Company

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***Abstract*—**In our research we aimed to test a managerial approach for the fuzzy front end (FFE) of innovation by creating controlled experiment/ business case in a breakthrough innovation development. The experiment was in the sport industry and covered all aspects of the customer discovery stage from ideation to prototyping followed by patent application. In the paper we describe and analyze mile stones, tasks, management challenges, decisions made to create the break through innovation, evaluate overall managerial efficiency that was at the considered FFE stage.

We set managerial outcome of the FFE stage as a valid product concept in hand. In our paper we introduce hypothetical construct "Q-factor" that helps us in the experiment to distinguish quality of FFE outcomes.

The experiment simulated for entrepreneur the FFE of innovation and put on his shoulders responsibility for the outcome of valid product concept. While developing managerial approach to reach the outcome there was a decision to look on product concept from the cognitive psychology and cognitive science point of view. This view helped us to develop the profile of a person whose projection (mental representation) of a new product could optimize for a manager or entrepreneur FFE activities. In the experiment this profile was tested to develop breakthrough innovation for swimmers. Following the managerial approach the product concept was created to help swimmers to feel/sense water. The working prototype was developed to estimate the product concept validity and value added effect for customers.

Based on feedback from coachers and swimmers there were strong positive effect that gave high value for customers, and for the experiment – the valid product concept being developed by proposed managerial approach for the FFE.

In conclusions there is a suggestion of managerial approach that was derived from experiment.

***Keywords*—**Concept development, concept testing, customer discovery, entrepreneurship, entrepreneurial management, idea generation, idea screening, startup management.

I. Introduction

MODERN management science has a big knowledge gap in the fuzzy front end of innovation (FFE) of the new product development process (NPD). The Product Development and Management Association (PDMA) defines the FFE as the activities that come before the more formal and well-structured (e.g. Stage-Gate or PACE) NPD process [1]. General concepts of FFE are in place. They give overviews of process and objects involved in the FFE. However, it is still work in progress to explore and understand effective management tools of the FFE. Further research focused on investigation of particular management qualities in each NPD case is needed. The accumulated knowledge would help to create a pool of roadmaps for managers to establish effective process in the FFE.

In our research we aim to test a managerial approach to the FFE by creating controlled experiment/ business case in a breakthrough innovation development. Owners of the chosen business case work in frames of entrepreneurial startup initiative to simulate the fuzzy front end. Managerial decisions in the experiment had freedom from any other institutions. The experiment was in the sport industry and covered all aspects of the customer discovery stage from ideation to prototyping followed by patent application. In the paper we describe and analyze mile stones, tasks, management challenges, decisions made to create the break through innovation, evaluate overall managerial efficiency that was at the considered FFE stage.

II. Study of the FFE in a Product Driven Startup

A. What Are the FFE Stage Issues

The Product Development and Management Association (PDMA) defines the FFE as the activities that come before the more formal and well-structured (e.g. Stage-Gate or PACE) NPD process [1]. The leading researchers in management investigate and describe FFE by putting its complexities and uncertainties into various models: the customer development model [2], lean startup [3], and new concept development model [4]. All of the models share in common relationship or looping back structure of iterations until the required "gate" or check point results are obtained.

Dr. Robert Cooper stated:"…many companies already have a solid idea-to-launch process or Stage-Gate® system in place……But a solid idea-to-launch process is not enough: What many senior executives are realizing is that there is a real shortage of strong, high-value ideas…In short, the process is robust enough, but the cupboard is bare – the pipeline feed is dry" [5].

In a product driven business (not market driven and not-me-too) of a breakthrough innovation a huge challenge is opportunity analysis, idea genesis, idea selection, idea screening, and concept definition. Quality of the related activities and their results feed the pipeline of NPD in a company. Even perfect and robust management of NDP has a great chance to fail if the quality of the FFE's results is questionable.

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However, by definition the FFE is less formal and less well-structured [1] than other parts of the NPD process. "Less formal and less well structured" is a "politically correct statement" to outline a huge gap in management science of FFE in compare with knowledge and methods at the other end of NPD process, like stage 4 (testing) according to Dr. Robert Cooper [6].

B. Quality of a FFE Outcome or Milestone

To be specific in describing FFE we should define a goal or milestone that one would aim to reach through managing of activities and recourses. In our opinion this outcome/milestone can be a concept of high quality product or service for further prototyping. At this point it is also important to introduce metrics / measures of quality of the product concept or service.

In our work by Quality, hereinafter called Q-factor, we mean that product concept is build using reliable information and analytical inferences that reflect external reality. For example, in physics and engineering Q-factor is a measure of resonant circuit effectiveness; the higher Q value indicates a lower rate of energy loss relative to the stored energy [7].

We see a great value of quantitative scale for Q-factors of the FFE's milestone, of course, pre-developed underlining measuring methodologies and instruments are needed. In this sense the FFE Q-factor will estimate or measure the correlation between "energy" or resources (including time) loss/expenditures and the commercial potential of the product in existing business reality.

The analogy with resonation in physics is appropriate association to estimate how the product concept resonates with existing reality of stakeholders' wants, needs, problems, and pains.

In this paper we introduce and use Q-factor as a measure of qualitative assessment. In our ongoing research we will focus on data analysis aiming to propose a quantitative approach for Q-factor measurement and scaling.

Notion of idea and its relation to the FFE, Q-factor, and product concept

We omit possible philosophical discussion about the meaning of idea proposed by Plato, Rene Descartes, David Hume, Immanuel Kant, Thomas Jefferson, and many other outstanding minds. We would like only to stress that from human science idea construed as mental representational images of some object. A mental representation (or cognitive representation), in philosophy of mind, cognitive psychology, neuroscience, and cognitive science, is a hypothetical internal cognitive symbol that represents external reality, or else a mental process that makes use of such a symbol [8].

From the above definition follows that product idea is a hypothetical internal cognitive construct that represents external reality. This means that one can regard your α-prototype as an idea of the product because there is not yet customer validation and, hence, the future marketed product can have completely different features or even there might be a new "idea" for product and business. The other one can regard your product idea as a final product based on his external reality representation. The presentation of innovation to a venture fund if not based on solid statistics of sales would be considered by investment manager as the idea for product and business even if there was a "physical product" on a table. At the same time a business angel, friend, or investment manager from the other venture fund could regard it as a product for new business. Here we may meet significantly different notions of what is considered an idea of product and business or as product and business among various stake holders.

We can say that a product concept is a person's mental representation based on synthesis of his/her experience in the industry, how he fathoms industry problems and priorities, industry business process and technology limitations. For sure, the Q-factor of the product concept becomes a function of this external reality representation factors.

If an entrepreneur or intrepreneur is responsible for high Q-factor of a product concept, than as an expert he/she is responsible also to fathom corresponding industry factors, and to accomplish it in efficient way as a manager would. At a certain extend entrepreneur is not a person but a team. It is like a hypothetical human being with multiple "hands" and a pool of required competences to make things done. However, there must be a team leader that takes full responsibility for the whole startup success. The team leader's vision and decisions play a key role for a product concept creation. Our analysis shows that his role at the FFE should be an integrator of "external reality" to synthesize final version of a product concept with assistance of others.

Easy to say but how manager in a product driven startup can accomplish this challenging FFE stage with a high Q-factor product concept. The aim of our experiment is to explore possible option in managing FFE of innovation development.

C. Empirical Grounds for Planning of the Experiment

Authors were the managers of the Development Track of the Intel global program "Make It Wearable". Our responsibilities included training, coaching, mentoring, and application composition for these 36 projects. This work made us possible to gather the whole picture necessary to understand wide spread problems of the FFE stage in entrepreneurial startup teams that were product driven and base on engineering experiences.

The DEVELOPMENT track focuses on concepts that are both excitingly innovative and feasible to execute. The goal was to identify groundbreaking new wearable technology opportunities among participants and offer entrepreneurship training to the selected finalists which would accelerate the development of disruptive wearable technology into commercial products (www.makeit.intel.com).

During the DEVELOPMENT track we discovered that startup teams disregard quality of activities related (according to Peter Koen) to opportunity identification, opportunity analysis, idea genesis, idea selection, and idea screening [9]. Their primary focus was on technological prototyping and testing iterations rather than investing into high value product concepts development. Whilst, quality of the considered

concepts was rather dubious, and underlining information/data was invalid.

The mentioned above approach - focusing on prototyping and testing - looks effective for market driven projects with fast growing markets or oligopoly markets with a few major players where one can find a niche with a bit "better", a bit cheaper product /service. For example, in some market situations that could be a strategy for internet or software startups; like copy of established internet services on the other national market where this service is an innovation. Strategies are often based on as fast as possible prototyping and testing cycles with a comparatively short and superficial opportunity identification, opportunity analysis, idea genesis, idea selection, and idea screening. Prototyping and testing cycles can be accomplished in less than a few weeks.

Thirty six NPD startups of the Russian part of the Intel Development track were product driven without fast growing or oligopoly market advantages; thanks to existing situation in wearables market. However, all of them disregarded quality of results derived from opportunity identification, opportunity analysis, idea genesis, idea selection, and idea screening. The consequences were the unreliable base for the follow on concepts and prototypes development, or firsthand reliable information but with incorrect generalization inferences.

It was found that disregard of high Q-factor product concept development before prototyping is a consequence of psychological matter derived from leading positions of technology people in a team. These team members feel themselves more comfortable doing what they were trained to do for years– prototyping on the basis of technology platforms. It is worth to mention that most of these technology platforms are not for rapid prototyping. In the Development track in Russia entrepreneurial teams had three month of the "design thinking school" training, based on HPI at Stanford and Potsdam methodology [10]. Unfortunately, it appeared that knowledge and skills in "design thinking" methodologies were not of much use in such a situation of technologists leading the team. This was the result of behavioral and psychological issues why product prototype preceded a product concept derived from the design thinking approach.

Once the management of the Intel Development track shifted to the extent where the author's personal decision was to search for a way for an entrepreneur without industry 'stars' in his team, to build innovation concept of a valuable product/service or product/service with high Q-factor. By this time there was a clear understanding that all 36 teams miss managerial priorities and management practices of the FFE of innovation that resulted in product driven startups being bingo games with sense of strategies to win.

D.The Experiment

The project chosen for management, experiment and approbation was a new product development for swimming and aqua fitness. The goal of our research was to discover managerial features at the front end while developing a new product in swimming industry through entrepreneurial initiative.

To simulate the FFE of innovation development and its reliability we put the following constraints and assumptions over the experiment:

- Owners of the business case don't have the industry expertise, skills in technologies required to prototype the product and to manufacture it;
- Owners of the business case have knowledge and skills in NPD;
- The business case must be product driven (not market driven) and not "me to";
- The innovation must be new-to-the world;

In short the owner's "zero" industry knowledge and technology skill ensured that NPD would be unstructured and not formal. The "not market driven" and "new-to-the world" assumptions ensured that there was unstructured NPD process without shifts to managing development of additions to existing products or improvements /modifications.

Profound counselling with and assessment of master coaches of Russian's Olympic swimming team gave birth to the idea of a new product and direction for experimental business case.

Why have we chosen coaches of the Olympic team? We decided to find extreme users, and high level experts being in one when an idea generation issues appealed for the NPD case development. Of the highest value for our research was to find such a person, who would combine deep practical knowledge in training, have information hub for advanced innovations in the swimming field, and personal emotional relation to coaches' and high level swimmers' needs/problems/pains.

We aimed to test the hypotheses that in pre-prototyping activities one of the ways to maximize business efficiency was to get information from a trusted person that had the following qualifications: (1) has deep knowledge of related business process in the industry, (2) holds a position to receive product/service offers as beneficiary or as an advocate of the beneficiary, (3) holds a position capable of testing of developed prototypes in his/her business operations. The experience of "design thinking" classes showed a big value and efficiency of opportunity recognition and idea generation techniques. However, the results of a "manual" tool, the success of the implementation does not solely depend on the quality of a "tool" but also on a craftsman experience, and quality of material taken for processing.

Usually there is a prejudice that an idea itself is worth nothing. However, this statement underestimates a source of information and a person's experience which are synthesized in the idea and product concept. Our vision was to get that pre-qualified person or persons and at the first meeting get a general outline of product concepts as a mental representation of their existing reality. In contrast to them the authors had no discipline in swimming industry, and we didn't have the luxury of time to get it. Hence, the product concept generated solely by us, had a great chance of very low Q-factor just like a probability to win in Bingo game. So for our experiment (and NPD project) it was the FFE "endeavor" with the managerial responsibility to get high Q-factor prototype in a limited time frame. There was still a question: How can

entrepreneur deal with time–to-outcome and data reliability uncertainties in this situation?

In our study idea is a mental representation of product and business. And it is a human hypothetical internal cognitive symbol that represents external business reality. Hence, entrepreneurs' mental representation of product and business must at least fit external reality. For entrepreneurial teams "Design thinking school" methodologies could help to reach that compliance but it would require unpredictable number of iterations and timeframes since the startup team members didn't have required industry expertise needed for the chosen innovations development.

In our NPD case we tested the hypothesis that the projection (mental representation) of a new product, even in a general form, of a person obtaining:

(1) deep knowledge of related business process in an industry,
(2) a position to receive product/service offers as beneficiary or as an advocate of the beneficiary,
(3) a position to test developed prototypes in his/her business operations,
(4) a position of trust (no conflict of interests);

would give to the entrepreneurial team a lacking perception of a new product mental representation with a compliance to external business reality. From managerial point of view it will give more predictability to timeframes required to develop the new product that could be regarded as a break through innovation.

One should also take into account that building relationships with that kind of a person is a business process itself that requires time, planning of tasks and goals, and resources to be allocated for partnership development. At startup with limited recourses, including human ones, the team has always to weight and decide –what to focus on and in what timeline.

Instead of going into field research personally to learn industry business process, customers' problems/pains, we decided to focus on relationship building to get through fuzzy front of innovation. Comparative analysis showed that business process of relationship building would be more efficient than the field research to build authors' own mental representation of the innovation product that fit existing reality. Moreover, exactly this tactics fits university related startups/entrepreneurs very well due to the networking nature of university institutions.

University networks were one of the major facilitators for us to get to and to establish working relations with coachers in the Russian Olympic swimming team.

At the first meeting with master coaches, after rapport building, we got general overview of training processes, equipment, methodologies, hydrodynamics, and coachers' insights of "it would great if a swimmer or a coach could". As a result of the meeting we had several ideas describing main feature of each possible innovation and understanding of their priorities (need/problem/pain).

We devoted three-four weeks between the first and the second meetings to assessment of the technical side of solutions (product concepts) prototyping and mass production; what type of a product could be and in what type of a business model it could fit. We met technologists and engineers to found possible (constraints) barriers and tech milestones of development tracks. The next management decision the authors had to take in order to answer the question «What is the pain that we can address with a prototype created just in a few months, considering the current resources and technologists available for us?".

The second meeting at the base of Russian Olympic swimming team was devoted to gather as many details as possible on the following point of view: how one can help a swimmer to feel water in 5-10 minutes of training". The ability to feel or sense water is the most important sensation for good swimmers. The quality of this sense is not stable and differs with the time, becoming better or worse. Even Olympic level swimmers lost it regularly after hand paddles or gym trainings. Attempts to find water feeling can be a long training process. Sometimes it requires days and weeks.

As a result of the second meeting we had a point of view formulated by the coachers that between palm and water there can be air with different pressure:

- Low pressure with air medium between palm and water would give swimmer ability to feel water immediately after taking the medium away;
- Higher pressures with air medium between palm and water would give training effect like hand paddles but with extra feature of resistance adjustments during trainings;
- Variations of air pressure give device capability to transfer trained swimmer's power to swimming speed instantly.

In that way the entrepreneurial team formulated the concept of a breakthrough innovation (not a product yet) just after two meetings with the right people (qualification/profile was given above) and after one month of part time work on the NDP project.

The concept is as follows: "A device for training is designed as a covering, shaped to approximate the shape of a swimmer's hand during stroke. The device is made of elastic material that hugs the entire surface of a hand and on an inner side of a hand it has at least one cavity that allows you to create overpressure of air or other gas. The device changes its volume and mechanical strain of the elastic material in the area of an inner side of a hand due to pressure changes. The device has at least one valve for pressure changing in the cavity".

The next two month after the concept formulation team worked on developing the right combination of technologies required to create the working prototype. Criteria were the following:

- Prototyping technology is the same as for mass manufacturing;
- Technology lets business to fit certain direct cost;
- Technology minimizes number of operations for mass manufacturing;
- Technology provides right (desired) product features.

The technology quest covered about twelve weeks. It was structured in the following stages:

- Get to know technology through internet and follow on expert facilitation;
- Get basic skills for using it by creating a prototype;
- Test the prototype technical features, for example, resistance to chemicals in swimming pool and mechanical resistance;
- Test by members of the team prototype's consumer features in a field, in our case, in a swimming pool training.

Through several loops there was a working prototype of the product by using technologies and chemicals that fit above technological criteria.

The major managerial challenge in the "technology quest" period was supply of components for prototyping and outsourcing of some technological operations that require specific equipment. Accessibility to purchase materials and equipment had barriers of time to supply and in quantities to buy. This leads to an inference that the more general product concept one has than the more time and resources will be spend for work with supply chains. Each feature to prototype could regard managerial uncertainties in supply chains to overcome. When one put frames for the FFE stage there should be take into account situations when prototyping requires materials and operations with limited or no offers on the market.

In our research we made an assumption that the FFE of innovation ends with the high Q-factor product concept. In our paper the prototyping stage and follow on prototype testing is needed to make estimation of the Q-factor of the developed concept. However, there can be cases with no infrastructure around that could support the product concept prototyping: suppliers of specific materials, components, software, equipment, technologies, or competencies. Our opinion is that in those cases managers must include prototyping in the FFE of innovation development. In the research case we discovered that potential uncertainties, however, in our case they were all required to prototype on the market. Issues were related to longer times-to-supply and larger min volumes to buy.

Before there was a prototype for α-test there were 9 failures in technology application. The reason of all of them was the lack of knowledge in polymer materials and their applications, and nuances of their technology processing.

At the third meeting with coaches of the Russian Olympic swimming team there was presented the working prototype of break through innovation that gave swimmers ability to gain water sensing/feeling in 5 min of training. For Olympic level swimmers it is extremely important to obtain it right before competitions.

Tests had outstanding results, the value was absolutely high – all swimmers got strong positive effect in 5 minutes of training with the prototype. In terms of sizes and durability of pressure valves connection we had minor (critical) adjustments to make. First ten prototypes after the first short tests were so popular that there was rivalry to get them for further trainings. We got an instant order to produce 15 more pares of the prototype for those who tried but didn't get spare ones. Also we got real partnership activities by putting our product development process into schedule of Olympic swimmers in next team gathering in October 2014.

III. Results and Discussions

In the experiment to reveal the FFE managerial issues we looked at pool of companies participated in trainings and coaching sessions of the Development Track of the Intel global program "Make It Wearable" in Russia. All startups:

- were product, not-market, driven;
- had leaders with strong technology/engineering background;
- look for business opportunity in radical innovation through product concept development;

This research phase revealed lack of efforts those entrepreneurs devote to a product concept development before prototyping and testing (here, prototyping excludes raw prototyping like sketching, mold from plasticine or paper). Product concept development for further prototyping was the most mysterious or fuzzy process from a management point of view.

So there was a decision to explore a possible management approach that would give outcome - product concept for further prototyping. This assumption has an open issue whether in all cases the FFE stage is over with a valid product concept in hand. We think that the FFE can be extended to prototyping in situation when supply of required for prototyping materials, components, software, technologies are limited or none.

In the experiment prototyping and testing were used to verify the product concept value for customers, or in other words, to verify that the managerial approach in the FFE created the required outcome – high quality product concept.

In our paper we introduce hypothetical construct "Q-factor". Q-factor is required in our study to distinguish among product concept as outcomes of the FFE management. This hypothetical construct determines quality of a product concept. We use it as qualitative measure to estimate the FFE stage outcome.

The experiment simulated (imitated) for entrepreneur the FFE of innovation and put on his shoulders responsibility for the outcome with the high Q-factor. The FFE situation was ensured by the entrepreneur's knowledge in the swimming industry that prevent him from structured and formal business planning in breakthrough innovation development. The product concept was prototyped and tested to estimate quality or Q-factor of the product concept.

While developing managerial approach to reach high Q-factor outcome there was a decision to look on product concept from the cognitive psychology or cognitive science point of view. There is interesting fact that idea is a mental representation of reality. Based on this view we come to a conclusion that product concept is an idea. Or product concept is a mental representation of reality. By comparing how differently humans regard the same product as an idea of product or the product one can see how perceptions of existing

reality is differ.

In the experiment we tried to formulate managerial approach on the basis - how quick and with minimal recourses one can get a product concept that match existing business reality.

The approach was formulated through development of the ideal profile of a person who had perfect mental representation of existing business reality:

(1) deep knowledge of related business process in an industry,
(2) a position to receive product/service offers as beneficiary or as an advocate of the beneficiary,
(3) a position to test developed prototypes in his/her business operations,
(4) a position of trust (no conflict of interests);

So our managerial approach was to qualify persons based on this profile and to invest time and resources into relationship building. However, one can make a decision not to follow other person mental representation and to form his/her one. In the management perspective this decision required different type of activities and business process.

Through different opportunities there was found the qualified person. He was a master trainer in the Russian Olympic swimming team. This person indirectly set the industry direction for the experiment. If the qualified lead was found in the e-commerce industry the experiment can be in this field. Choice for industry direction is also an interesting inference from the experiment – the qualified person determines entrepreneurial opportunity; the whole project was build around his qualification, however, he/she is not part of entrepreneurial team and could be regarded as a long-arm partner. The word “expert” or “expertise” is omitted due to more complicated partnership roles in play.

Following the managerial approach the product concept was created to help swimmers to feel/sense water. The working prototype was developed to estimate its Q-factor.

Based on feedback from coachers and swimmers there were strong positive effect that gave high value for customer.

The patent application was submitted in August18, 2014 to set priority. Its registration number is 2014133753. The US patent application will be submitted during October-November 2014.

The Q-factor of the product concept is regarded as high based on the following results:

- validated high added value to swimmers in solving water sensing problems;
- innovation from patent search is a breakthrough;
- time from “zero understanding” of swimming industry by entrepreneur lead to the product concept in one month.

IV. Conclusions

In case of a product driven startup in FFE stage we would like to suggest for an entrepreneurial team leader the following managerial frame:

- your ultimate goal (primary outcome of the FFE stage) is to deliver product concept with a high Q-factor;
- set the profile of person in the industry you aim to do business, or use the general profile proposed in the paper;
- make correct qualification of the persons,
- invest time and money into relationship building,
- use his/her provision of the product (mental representation of existing business reality),
- prototype and give this prototype to the person for testing.

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