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The process of user-innovation: A case study on user innovation in a consumer goods setting

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Manufacturers usually benefit by dividing their innovation processes into distinct phases in order to ensure that the development activities are performed efficiently in an appropriate sequence [1]. Users usually do not apply such structured processes. They follow a more intuition-driven approach. In this paper we analyze the way users improve or develop novel products. The field of our research is a new and rapidly evolving consumer market, the sport of kite surfing.

We identified a sequence that underlies the approaches of user inventors. This sequence consists of two major stages, (1) idea generation and (2) idea realization, each again subdivided. We propose that a manufacturer in the relevant product field can significantly profit from more closely observing such user activities:

- Better understanding of tacit needs which cannot be derived by applying classical market research methods [2].
- Learn about the adequacy of solutions from the user. This may guide their development activities and prevent development of inadequate solutions.
- Collect user ideas as well as corresponding solution knowledge at very low tariffs and increase reputation as a customer-close organization

1. Introduction

Empirical research has shown that users are an important source for innovations. Users have been found to be the inventors of reliable prototypes of what later became successful products in different markets [3] ranging from scientific instruments [4] to semiconductors [5] software and bakery goods [6], the construction industry [7] and library software tools [8], to mention only a few. Most of the early studies focused on the investigation of users in industrial markets or professional users (i.e. not consumers or private users). However, in the last few years more and more studies have been conducted in consumer markets as well, mainly in the market for sports equipment [9; 10; 11]. These studies in general found the same patterns as the studies conducted in an industrial environment: End users, likewise, seem to be willing and able to develop substantial ideas, concepts and prototypes for new products.

Besides the mere evidence of the existence of user innovations, research has tried to develop an understanding about "how" users innovate. First, empirical studies have investigated the factors that might prompt particular users within a user population to start innovation activities [9] . It was found that innovating users are characterized by a higher need for innovations and higher innovation-related knowledge. Second, since innovating users are often members of user communities, other researchers have investigated the process by which the inventors obtain innovation-related resources and assistance from other users. They find that assistance and the innovations themselves are freely shared within user communities [10].

While at least preliminary understanding exists about the triggers and the community-related aspects of user innovations, yet, there are – to our knowledge - only limited attempts to comprehensively explore the process by which end users do their innovation work. Specifically, there is a need to take a closer look at the sequence of activities users perform in order to develop ideas for new products and to transfer their ideas into concepts and reliable prototypes.

Knowledge concerning the processes of consumer user inventions is of theoretical interest as well as practical relevance, especially for manufacturers that actively aim to become a customer-close operating organization. Empirical research can provide interesting insights into what the actual problems of users are and which efforts users undertake to overcome barriers in the course of idea generation and prototype development. From these insights manufacturers may derive new approaches to actively support users and to increase the probability for them to develop solutions with a high technological and market potential.

Similarly, manufacturers that understand the problem solving process of user-innovators may be better prepared to signal that they are competent partners in the development process. By this, they can increase the probability that the innovating users get in contact with them instead of trying to develop by themselves or refraining from their inventions.

When focussing on the procedure of how end users innovate, it seems reasonable to compare their innovation processes with the phase models and activity sequences that have been suggested and explored for typical new product development projects in established (manufacturing) firms. After all, the systematic application of stage-gate-innovation processes and supporting tools have been shown to significantly improve the success of innovation in industrial as well as in consumer goods markets [1; 12]. By applying systematic approaches manufacturers expect to leverage their human and financial resources effectively, particularly in the case of incremental innovations. Through applying these structured approaches complex processes become understandable and manageable. Thus the question arises if end users apply a comparable systematic approach like established manufacturers.

We believe that even though consumers will not apply a structured methodology there still will be an underlying sequence of their processes which is similar for all consumer-inventors.

Reasons for not dividing their work into distinct phases are manifold: the sharing of the different tasks in the industrial innovation context, divided between functions like marketing, R&D or production, is not reflected in the users' innovation-task. They mostly do it by themselves and in this sense incorporate all relevant functions including the consumption. Their work is mostly done on a trial-and-error basis ("probe and learn"). This does not make it necessary to create detailed lists of specifications and instructions for engineering or design. Further, the process itself is rich in creativity and instinctual learning. Applying regulated procedures might reduce such creativity and hinder a rapid procedure. Users neither have the time for all of this, nor the resources (money) nor the awareness that this would be useful to apply. Finally, many users might not even be aware of the existence of such procedures.

Users often invent a product with market potential without being aware of the fact that they do. They want to improve a product or change it in some way to better suit their needs. But they do not really notice at this stage that they develop an innovation which eventually might even attract other users' attention.

The paper is organized as follows: Section 2 provides a brief discussion of the relevant literature. Section 3 describes the methodological approach taken and presents our research

questions. Section 4 describes the identified process underlying the user-innovation, and Section 5 provides a discussion of the findings and implications of the study.

2. Literature review

The role of process models in New Product Development

(Business) processes are a key element of management theory as well as management practice. Many of these processes have been studied thoroughly [1; 13; 12]. But why is there such a great emphasis on understanding processes? Most studies exploring business processes aim at developing models and tools in order to increase the efficiency or effectivity of business activities The different stages of a process are defined, key steps are identified and relevant success-factors are derived [1].

The deep understanding of processes helps to derive success-factors. By understanding the processes of one group of users another group of users can modify and apply success-factors of the other group to their own specific needs. This way a transfer of ideas and activities can be achieved. An example for this is the Japanese car industry. Management and production methods like lean management, lean production and Kanban of Japanese companies have been adapted to the needs of western companies and have been successfully transferred to them [14; 15].

Hence it can be summarized that the understanding of a process can lead to the understanding of the ideas and triggers behind it. Assuming this holds true, analyzing the process of user innovation might lead to the application of better approaches and techniques for other users or even for manufacturers. Furthermore it would be of great help to understand at what stages users encounter problems in the process. Understanding where they need support might help companies develop a better reputation with users and would increase the readiness of users to inform the company about their activities. Thus they might be able to derive new products from this input.

The importance of user inventions

Users have been found to be an important source of innovations [16]. They appear to have a unique way of identifying problems and seeing ways to increase the usability of products that manufacturers do not have. The question arises why users (as was often found in our interviews) do not just tell manufacturers which problems they encounter and get them to develop the products. This would be logical as manufacturers are seen as the locus of problem

solving capabilities. The difficulty to transfer information from the users to the manufacturers seems partly to be due to the "stickiness" of information [17; 18; 19; 20]. The stickiness of a given unit of information is defined as the incremental expenditure required to transfer that unit of information from its point of origin to another party [21].

Ogawa [19] showed that the stickiness of innovation related information is critical for the prediction of the locus of problem solving. Manufacturers usually possess the knowledge about the technologies and develop problem solving skills for new product development. The users mainly possess knowledge about the product use and the user needs. If both, the technical problem solving skills and the knowledge about user needs are sticky, neither the users nor the manufacturers will be able to develop reliable solutions. It seems probable, that innovating users will therefore terminate their inventive activities because they lack the necessary problem solving skills. From interviews with users, our assumption was supported that there are more reasons to not transfer knowledge to a manufacturer than just the difficulty of the very task. Lack of interest to listen to users or the non-existence of useful communication channels of a manufacturer is one [2]. Manufacturers should bear in mind that customer related information can only be obtained from customers as they have "discretion over the resource" [22]. There lies a disadvantage in not transferring problems to manufacturers that users cannot solve themselves, as the best ideas of users may never, or at least not until much later, be developed. The users do not have the problem solving capabilities and the manufacturers despite possessing the problem solving potential do not yet see the problem.

The question why users have the best insight into problems related to the use of products is answered by von Hippel and Tyre [18]. They found that "doing did appear to be closely associated with problem identification in the field".

Need for research of user invention processes

Systematic as well as structured processes foster the success of innovation [1; 12]. Cooper argues that successful innovations that have been developed without a "game plan" or "stage gate process" are more or less incidental. By breaking up the innovation process into a series of stages separated by go/ no-go gates the whole process becomes disciplined, tangible and assessable. The positive effects of such process guides has been shown in multiple studies [23].

The problem solving processes of innovating users are not clearly specified and most likely vary between different users. Promising ideas often require high problem solving capabilities

which users usually do not possess. So far it has not been analyzed at what stage in "the process" users fail in their attempts to develop a novel product. Do they actually start building the product and do they fail during the attempt or are they afraid of failing and therefore do not even start such activities? Is it always a problem users encounter that triggers them to develop a revised product?

There is a multitude of generic patterns of how users can approach a development process. What are their first activities, do they plan their development work, do they involve others in this process and what are the objectives they are heading for? Users are expected to invent novel products for themselves as they do not really care about the improvement their invention could bring to other users or the market [24]. But do they at least sometimes target a broader audience? Certainly different users will approach the development differently. Additionally different problems will require different levels of information gathering and planning.

By better understanding what appears to be the typical pattern of the development process of user inventions and identifying "stages" within such processes (e.g. where users refrain from further development because of a lack of problem solving capabilities or for other reasons), manufacturers could offer support and simultaneously gain from learning about the problems such users face. This might at first glance appear untypical as a manufacturer activity since this touches "their" role as a developer substantially. However, in the case of the software industry such support activities have been common practice for many years [25].

Maybe users always fail at a certain stage of the development process because they lack the required know how. In this case manufacturers could support them with the necessary know how or even offer them courses in which they could learn it. By understanding the process of user innovations manufacturers can conceive the problem awareness of users and thus can react better. Therefore the understanding of the process might lead to the ability to extract more and better user ideas.

3. Methodology

Setting of the Research

The field of sports equipment provides the empirical setting for this study.

Our reason for this choice was that, according to previous studies, users often improve the sports equipment they use ([26]; [27]). A minimum level of innovation activities on the side of the users is a prerequisite for exploring the process that may underlie these user inventions.

We selected the kite surf sport as the empirical field for this study. A kite surfer is loosely attached to a board and uses the power of a large, controllable kite to propel themselves across the water. Because of the strong pull of the kite it is possible to go at a high speed and perform large jumps in height as well as in length [28].

This sport is comparatively new and was first demonstrated to the public in 1985 [29]. (For more information see [30].) We therefore expect a level of innovation activity.

Additionally, kite-surfing is a combination of the equipment and skills of various other sports including windsurfing, wakeboarding and kite flying. Thus different backgrounds of users and sources of stimulation are present [31]. The more heterogeneous and multiple the related fields of user involvement are, the more different approaches can be expected [24], thus kite-surfing is likely to lead to a large number and variety of novel ideas and products.

The Sampling Frame

The target population consisted of the 405 members of the Australian Kite Surfing Association (AKSA). AKSA represents according to their own statement about 25% of Australian kite surfers. Expert interviews with kite surfers were conducted in order to better understand the sport and to assess if user-invention is a common phenomenon. Additionally they served to find out which parts of the equipment are especially interesting for modification by users. Furthermore, the intention was to understand the characteristics of inventing users, why they develop novel products, and what the development process might look like.

Questionnaire and Data Collection

As we hypothesized that there were different ways users approach the process of invention we aimed at finding a number of inventors who had developed particularly promising products to

obtain overall insights into their invention process. To do this, we used a written questionnaire and distributed it to the members of the target population.

On the basis of this survey, we were able to select the user innovators within the whole population. In a second step these inventors were to be interviewed to understand the underlying processes of the development of the novel products, to identify the main barriers in the process of invention. Additionally the outcome of the development itself (typically a reliable prototype) was to be analyzed in order to better be able to assess the "value" of the product in terms of technological and market potential. We asked experts in the field of kite surfing to validate the inventions.

In total, 405 questionnaires were sent out via surface mail. The envelope sent contained a short cover letter, the questionnaire, and a "postage paid" preaddressed return envelope. To increase the return rate an incentive was given in the form of ten one-year free-memberships for AKSA.

Of the 405 questionnaires, three were returned undelivered, reducing the sampling frame to 402. Of these, 157 questionnaires were completed and returned after one follow-up email. The achieved response rate is very satisfactory (39.1%). The sample was predominantly male (91.7%), 45.5% were between 30-39 years old, with 75% having a tertiary education. The majority (91%) had a background of related sports and 78% kite-surfed at least once or twice weekly.

Of the inventions described in the returned questionnaires five problem solutions appeared to be especially promising and were selected for follow-up. Criteria for the selection of these inventions was a clear description in the questionnaire and a high level of newness. A clear and detailed description was used as an indicator for the , had given the product a lot of thought and this indicated they had a strong need for it. Inventions that obviously only displayed minor modifications were not taken into consideration. The inventors were first contacted by telephone and then interviewed in person. They were asked to explain the trigger of their ideas, the product itself, the benefits they gained from it and the process which led to the development of the product. If possible, the product was examined and photos were taken.

The inventions

The five user inventions more closely analyzed were a new harness, boards, a length-adjustable bar, a trim system for fine-tuning in gusty conditions and a novel safety system. (for more information see [30])

The harness is a device used to strap the kite onto the body for relieving the pull from the arms and to enable practitioners to take both hands off the bar. The harness was classified as one of the most dissatisfying parts in the equipment. Reasons for the dissatisfaction were the lack of fit and comfort, reaching to descriptions of being painful to use. The most common problem the harness caused was the fact that it rides up from the waist and squashes the upper body and thus can be painful. The idea for the novel product consisted of the combination of a normal harness and wet suit pants firmly attached to it to keep it in place.

Kite boards very frequently were user built. However, as we later discovered, changes applied to existing designs usually only consisted in a different arrangement of foot straps or fins and therefore can only be seen as minor modifications. Most users only copied available designs to save money by not having to purchase the very expensive commercial products. Boards will not be in the focus of the following analyses.

The bar serves to steer the kite and thus to influence direction, speed and pull of the kite. To kite surf in different wind strengths more than one kite is necessary. Some kite surfers feel that depending on the size of the kite they need an individual bar for each kite. To circumvent this, this innovation simulates bars of different sizes through its adjustability.

The trim system is not a change of a commercially available product but delivers a new functionality. This system reduces the impact of wind gusts onto the bar and therefore onto the practitioner. It is like a spring that automatically opens and closes the kite depending on the wind strength and thus makes the ride smoother. This invention was classified by experts as a very interesting one. However, this would be a product only very versatile practitioners would be interested in.

A safety system serves to partly disconnect the kite from the kite surfer when they enter a dangerous situation. To disconnect, the practitioner lets go of the bar. Due to the safety system they are only connected via one line to the kite. Therefore the kite cannot catch the wind anymore and falls down. If the practitioner would let go completely the kite would be a danger to others. If they would not let go the kite could pull the surfer into obstacles and thus injure the user. The novel safety system displays a major improvement to the commercially

available system. The initial dissatisfaction with the commercially available products came from the dangers connected to them. When reaching a certain level of excellence the conventional safety system can become a danger. When the lines tangle the control over the kite is reduced and therefore control over the whole system can be lost. This danger can largely be reduced with the novel set-up as can be seen in Figure 1. Industry experts stated that they themselves are currently working on a very similar system. This shows that the inventing user here certainly is ahead of the market and the product they built by themselves will be introduced to the market soon.

Figure 1: Comparison of safety systems

For each new device a short case study was prepared. After the cases were written and checked by the inventors, industry experts were selected from the list of respondents to the initial survey. Criteria for the selection of these experts were either working for a manufacturer company and/ or being a well respected kite surfer. All experts selected had a long experience in kite surfing and knew the market for equipment and activities of manufacturers well. The aim of this was to get a more reliable evaluation of the inventions described due to their better overview of the products available than most inventing users.

The experts were asked to evaluate the inventions according to the perceived novelty and the expected acceptance in the market.

4. Results: Innovation-related activities of users

In the following section the user sample will be divided into different groups. The sequence of typical user-invention activities is described, first looking at the idea generation process and then at the product development/realization process. Finally the sequence of activities will be combined.

Segmentation of the user sample

The population can be divided into three groups: Inventors, idea-generators, and non-inventors. Inventors are those who actually developed a prototype of a product and use it. Idea-generators are those who generated an idea but did not proceed to develop an actual product or prototype. Non-inventors did not state that they had any ideas of how to improve their equipment. To derive a process and analyze what the different stages are and at which hurdles potential inventors fail, the division into the three different groups is required.

As can be seen in Figure 2, of the 157 responses, 45% (71) of the users can be seen as "active", i.e. either have developed an idea or built a prototype. Of these, 63% (41) have built a prototype, 28% (24) have developed an idea and the remaining 9% (6) did not state how far they got in the development process.

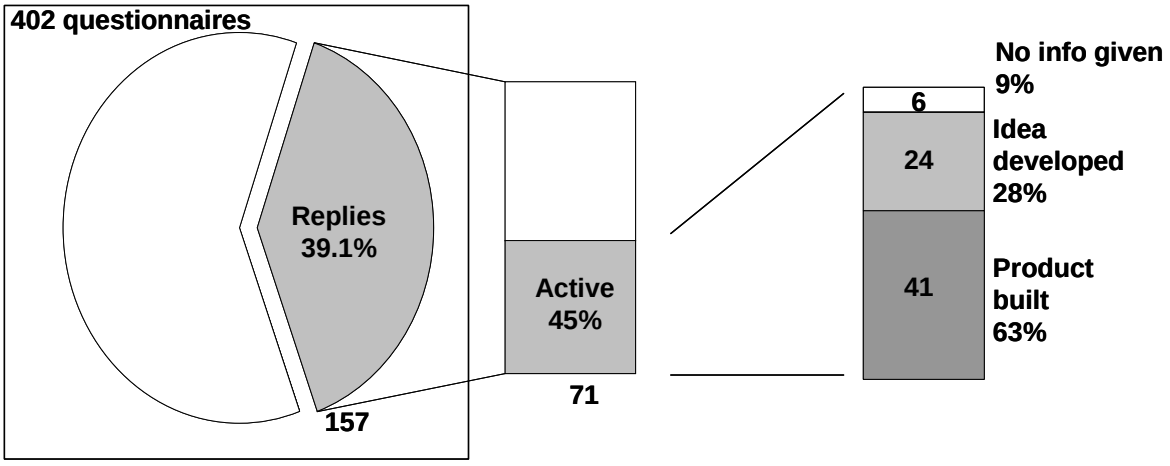

Figure 2: Evidence of User-invention

These findings affirm the findings in earlier studies. Franke and Shah [10] found that 32% of users in the sports communities they analyzed had innovated. Lüthje [11] obtained similar results. In his study on outdoor sports equipment Lüthje found that 37% of users had developed ideas for new products. Two different perspectives can be taken for our study. Either 45% of users were active, i.e. had generated an idea or developed a product or 26% of all respondents have developed a product. Therefore our study is in accordance with earlier findings concerning the approximate number of users in a community to be expected to invent.

Steps in the idea generation stage

Primarily a user has to be knowledgeable and experienced to be likely to invent new products. We found that users who developed ideas or the product itself to significantly better know their equipment than those who did not develop ideas. Furthermore they were very experienced practitioners who had a better insight into the activity than the majority of the

users who did not innovate. Knowledge and experience appear to be the base for the innovation process.

The knowledge-ability of inventing users was expressed by the fact that they often were consulted by other users when problems were encountered. They customize their equipment themselves and often have adopted other users' inventions. This item was seen as a good indicator because it relates to the concept of opinion leaders which has been shown to be important in the innovation literature [32; 33]. The free sharing of information which can be equated with the consultation by others has been shown to be an important aspect in user innovations by Franke and Shah [10]. Also in the community analyzed the openness of users and the willingness to inform other users and support them with know how were striking. The finding that they do not fix their equipment at first surprised us as we had found that they do possess the ability to do so. However, we found that they know their equipment well enough to be able to tell beforehand if it might break and thus there is no need to fix it. They do not need support of others and they do not consult others.

Experience is represented by the variables frequency of practicing the sport, number of competitions users had taken part in and related sports that had been practiced before. All these were found to be highly significant in a logistic regression as can be seen in Figure 3 (inventors vs. non-inventors). This table contrasts non-inventors and the group of idea generators and inventors. As we are looking at the idea generation process, it makes sense to combine these latter two groups as both have developed ideas.

Had an idea[a] * Knowledge-ability	Logistic Regression Sig.
Others consult me[b]	0.001
I adjust my equipment[c]	0.017
I have adopted other people's innovations[a]	0.038
I fix my equipment[c]	0.408
I know others who help[c]	0.464
I consult others[c]	0.775
Omnibus Model Sig.	0.000
Cox & Snell R Square	0.295
Nagelkerke R Square	0.395
Had an idea[a] * Experience	**Logistic Regression Sig.**
Participation in competitions[d]	0.003
Frequency of kite surfing[e]	0.007
Prior experience from related sports[a]	0.048
Omnibus Model Sig.	0.000
Cox & Snell R Square	0.226
Nagelkerke R Square	0.303
Legend	
a 1: No, 2: Yes	
b 1: Never - 3: Often	
c 1: Not at all true - 5: Absolutely true	
d 1: Never - 5: More than six times	
e 1: Less then 1x/ month - 5: Every day	
Source: survey set used: all n=152 (5 missing)	

Figure 3: Knowledge and experience

To conclude, our expectation that innovating users are more experienced and knowledgeable than non-innovators is supported by the data.

Depending on their experience, users encounter problems with their equipment. Less versatile users have very different problems than do users with high expertise levels. Expert users, in order to enhance their performance, bring the equipment up to the level of their abilities while less versatile users tend to address problems of comfort and ease of use. An example of equipment developed by expert users due to their specific needs is the system that fine-tunes the kite in gusty wind conditions. This system automatically changes the angle of the kite when a gust of wind comes and therefore the practitioner can be active even when the weather conditions are not favorable. A less skilled practitioner would be highly unlikely to develop a product like this as they would not expose themselves to such a difficult situation and hence do not encounter these problems. An example for an invention of a less skilled practitioner is the novel type of harness. This product is intended to make the ride more comfortable and distribute the inducted forces more evenly. An expert user, however, would not encounter the problems that led to the development of this product. They have sufficient control over their equipment in such a way that they do not face these problems. Even though

this invention allows the less skilled user to ride more comfortably, the evaluation of the products by industry experts has shown that the product developed by the expert user was seen to be highly interesting whereas the product of the less versatile user was not rated to be of great importance. The harness was classified as not having any market potential as it was seen not to be able to solve the problem addressed. In contrast, the fine tuning system was evaluated to have a good chance in the market – at least with experienced users.

Users who are knowledgeable and experienced and have encountered a problem do not necessarily invent new products. Some kind of stimulation is necessary that helps the inventor to be able to develop an idea of what to do and what to develop. We found two main sources by which these ideas are stimulated. One is the internal stimulation, from former experiences and other activities known to the user. The user who developed the length adjustable bar, for example, was stimulated by their experience in wind-surfing. The other type of stimulation comes from outside, from other users and people surrounding the inventing users. The typical mechanism of the outside stimulation is that a user explains their problem to another person from outside the community. This person suggests a solution from their background. The users normally never thought about this possibility because of a different background. An example is the fine tuning system again. A non-kite surfer suggested the use of bungee rope because of their experiences from bungee jumping. The inventor applied the rope and solved their problem.

Also the nature of the stimulation has to be considered. Two different sources are apparent. Either the stimulation comes from a related sport such as windsurfing or kite flying. An example for this is the modified harness. In windsurfing, a different harness is frequently used and the underlying ideas of this are transferred and applied to the kite surfing harness. The second source is analogous fields [34; 35; 36]. Here the example of the bungee rope (“fine tuning system”) is salient. The kite surfer was facing the problem with very frequently occurring wind gusts that disrupted their ride. Thus they realized that they needed some kind of spring to relax the strain. In bungee jumping the rope softens the retraction when jumping. Therefore a good solution of the requirements from the problem and the features of the available product are evident. Therefore as shown in figure 4 stimulation can be differentiated with respect to the subject (inside/ outside) and to the problem field (direct connection to related field/ analogous field).

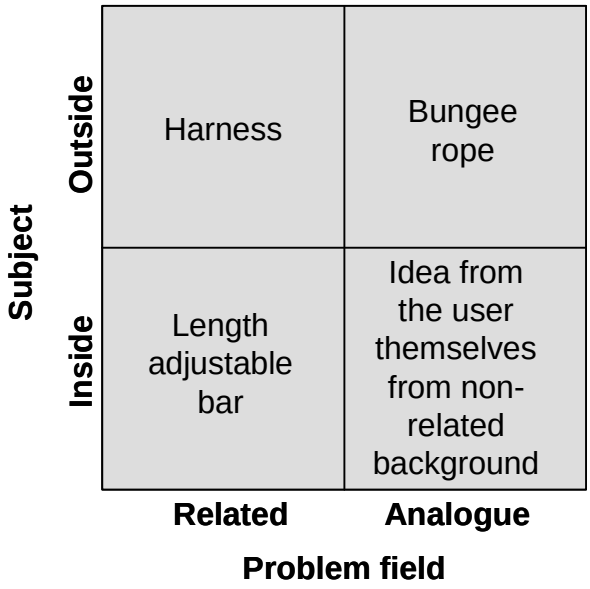

Figure 4: Sources of stimulation

After encountering a need through a problem and some sort of stimulation, the third step, the development of a concept, has to be approached. This concept usually is not developed in written form but rather a rough mental representation of what the product could look like and what the advantages are supposed to be is developed.

These three stages, given that the preconditions of knowledge and experience are fulfilled, are essential for the generation of ideas. Now the realization process can be approached. At the end of this first process a user has turned into what we call an idea generator in this context because they have taken the first hurdle in the invention sequence and developed a basis for the realization of a novel product. The idea generators usually enter the realization process but only some of them reach the end and become what we call product inventors.

Steps of the realization/ development stage

The realization sequence has a number of preconditions and some triggers that distinguish those users who have developed a product from those who only had an idea. Preconditions in this context are necessary requirements while triggers are the circumstances that motivate a user to actually invent. We next describe the preconditions for development followed by the triggers that motivate users to actually develop the products from their ideas.

Preconditions

The preconditions for the realization are the availability of tools and materials, the absence of time constraints, some kind of incentives to develop a novel product and the relative importance of the product part in question. We found from the interviews that all inventions

were based on either readily available tools and materials, or on materials that could be obtained easily and cheaply. This corresponds with findings of Lüthje et al. [37] in the field of user innovations in mountain biking equipment, where users used technologies “at hand”. No user bought tools or invested significant amounts of money in the materials. Most users already possessed the parts they needed. Tools were mostly simple household devices.

The inventor of the length adjustable bar, for example, used an old windsurf boom which they did not need anymore and modified it into the length adjustable bar. Thus there was no initial investment at all. However, after using this bar for a while and being satisfied with its functionality they discovered disadvantages of the setting and searched for an alternative which they were willing to purchase at a higher cost. Thus, while there was no initial investment, after the novel product had proven its functionality and value, the willingness to further improve it brought about the readiness to invest money.

Sometimes the material was not available, especially when the means for the solution were recommended by a person outside the user community. The necessary material, however, was very cheap – e.g. bungee rope, lines or hooks. It appears that users would not have developed the products if they had needed to spend considerable amounts of money. Certainly one of the reasons for not being prepared to spend a lot of money initially is the fact that users are not certain about the outcome of their plans. The fear to try to modify an existing product and while doing so to destroy it is an important restriction to inventions.

The second precondition is the absence of time constraints. Many idea generators reported in interviews that they did have ideas and even a concept of how to solve their problems but they were not willing to spend the required time. The time they did have available they preferred to spend with practicing their sport.

Another precondition is the incentive that the reputation of the user who builds a novel product is increased. This goes hand in hand with the fact that inventing users are consulted by others more frequently because of their higher reputation. Most user-developed products do not look as stylish and technically sophisticated as commercially available ones. Thus while using the new product other kite surfers will notice them just by the way they look. This initializes discussions between inventor-users and other users and can lead to an increased reputation of the inventor.

All parts of the equipment have been subject to complaints and ideas for enhancement. Users who built products rated the components they changed or developed to be very important parts of the overall product. From this we derived that a real need to build a product is

connected to the importance of the part. If, for example, safety issues or performance are connected to one part of the equipment it is more likely that the part will be built than when only the fit could be improved. The novel safety system was derived from an intense need due to safety problems. The conventional safety system is sufficient for users with a rather low level of expertise. However, users with a high level of expertise are hindered very much by the conventional system. They cannot easily do spinning tricks because the safety lines tangle which again reduces the reliability of the system. Standard users do not encounter these problems because they do not do these tricks. Many experienced users who face this problem do not use any safety system. This, however, should not be an alternative because the danger without a safety system increases dramatically and has led to fatal accidents. Thus, a fourth precondition for development is the importance of the part in question.

Triggers that motivated developers

When the preconditions have been satisfied additional triggers need to motivate the inventors to actually build the product. The triggers that appear to have motivated the developers are open-mindedness or the willingness to share and make use of knowledge of others and the willingness to invest time and effort into some trial and error process.

The readiness to accept and make use of knowledge of others appears to be an important trigger. If there is no information-transfer the likeliness of a development of a product seems to diminish. This is surprising as we found that most developments were undertaken by the inventor alone and not by a group. Maybe the group approach has been replaced by the preceding knowledge transfer. Franke and Shah found that “An individual may develop an idea, but developing this idea into a functioning prototype often requires the assistance of others.” [10]. Also Shah [9] found that many user-innovators founded life-style companies together with other sports-enthusiasts to build their own self-developed products for other users. This indicates that most developments have been undertaken by a group of people rather than by single users, even though this is not stated in their article. However, it is not clear how far the assistance reached. If assistance was mainly focused on supplying information it is in accordance with our findings. However, if it was heading towards assistance in the physical building process it is contrary to what we found. Developers of products seem to be open to other ideas. They are ready to use outside sources of information to succeed with the realization of their ideas. However, in our community even though it appeared to be a quite closely knit community the physical development work always is concentrated with the individual inventor.

One would anticipate that the possession of the required skills and know-how would be predominant for the development of novel products. This appears to be very much self-explanatory because someone who has no skills cannot build a product. All the same, it deserves some more attention. This is not as fixed as it appears to be at first glance. Most developers did not completely understand the underlying principles of the product. However, they learned the required skills "by doing" as a "seat of the pants engineer". Thus, skill should maybe be replaced by endurance and motivation. It often takes a lot of time and effort to enter a trial and error process. While developing the novel safety system the innovator built several prototypes and did experiments to learn how the set-up works. They replaced the lack of know-how by the required endurance to discover a solution.

A typical pattern of a user invention sequence

Based on the interviews we conducted with the group of very promising inventors we developed the following sequence of activities (see Figure 5) that appears to underlie their invention process. The concept can be divided into two stages which are derived from the division of the inventor-group into two. The first stage is idea generation which ends with the development of an idea. The second stage is the realization/ development of the idea. Both stages have a number of preconditions.

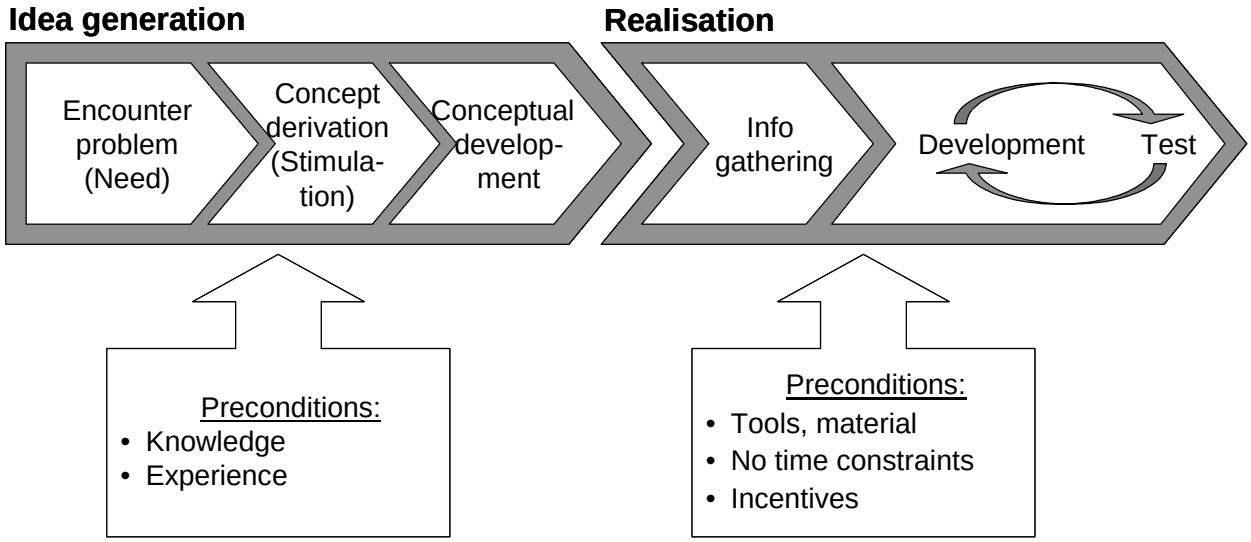

Figure 5: The User-innovation Process

5. Discussion and Further Research

An underlying sequence for the development of user inventions has been identified. This sequence consists of two stages, idea generation and realization. These stages again can be segregated into several steps. Idea generation has the preconditions of knowledge and experience. Users primarily encounter a problem, need some kind of stimulation either from inside or by an outside source. Then a rough concept is developed. The realization stage requires the availability of tools and material, the absence of time constraints, some type of incentives and the relative importance of the part to make the development more likely. Initially some kind of information gathering is required which usually consists of the exchange of ideas with other practitioners. After that a trial and error process begins. The developed product is tested, modified and tested again. This can be a single or multiple loop process.

The invention sequence is a process – although products are developed by single users – that depends very much on information exchange between users inside the community and with people outside of the community. The point in the process where idea generators and inventors are separated appears to be either the precondition of the importance of the part of the equipment or the fear of the strains of a long enduring trial and error process. It is interesting that the users who “only” generated ideas had a quite clear picture of what the product should look like and how this would be possible to achieve. Nevertheless, they did not build it.

We found no single user who began to build a novel product but was not able to complete it. Therefore the practical realization cannot be seen as a large hurdle. The actual hurdle rather seems to be of a psychological kind. Idea generators who do not build a product to become inventors do not even start the realization process.

All inventions were started by individual problems and the inventors only wanted to solve their very own problems. There were no aims to target a market or incorporate other users. When asked about their inventions the inventors were willing to share their knowledge and explain how they developed the product to other members of the community to enable them to copy the process.

Implications

We demonstrated that users very much depend on information exchange with each other and with others outside the user community. This information exchange can reduce the fear of

users to create their own inventions. Manufacturers could organize fairs for practitioners for them to inform themselves not only about the newest equipment but also be able to talk to expert equipment builders and start discussions among the users. Alternatively a guide book could be embedded in an online portal where users could exchange information about equipment and their experiences with user-built novel products. This way, manufacturers can simultaneously scan user ideas and apply them to their own innovation activities. Two hurdles for inventing users can be reduced with this approach. The information exchange which has been found to be very important for the activities of the users would be supported and the lack of knowledge about the different parts of the equipment would be reduced. Furthermore, the knowledge of users who were able to develop their own products might encourage other users who otherwise would restrain from the activity. The manufacturers could leverage the ideas posted on the portal and enhance their image as a user-supporting company.

Further research

It is of great interest to more closely determine the stage where users discontinue the invention project and if there is a specific hurdle in the process that often leads to this. The reasons why users discontinue at these stages need to be disclosed. Additionally a more elaborate sequence of user innovation related activities in greater detail is desirable.

We would like to stimulate other researchers to formulate ideas and conduct their own research on the topic as we feel that there still is a gap. We are of the opinion that the knowledge about the invention process will help researchers to better understand why users invent, and for manufacturers to better gain from user inventions and user ideas.

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