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User Technique Innovation in the Innovation Model: A case study analysis

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Abstract

Not only companies develop and innovate products. An important role is also associated with the users of products. Users innovate products to benefit from using the innovated product, whereas companies expect to benefit from selling the innovated product. Companies obtain inputs from user innovation, which they use for their own development and innovation. A specific type of user innovation is user technique innovation. Technique innovation is innovation in the use to which an existing object or tool is put. In the literature, there is limited coverage of the occurrence and diffusion of user technique innovation. Furthermore, in the literature, it is not known how user technique innovation can provoke product innovation (user technique innovation-driven product innovation). Therefore, this thesis aims to provide more insights into the origin and diffusion of user technique innovation, and insights into user technique innovation-driven product innovation. This is executed by analyzing four new cases where user technique innovation eventually led to production innovation. Similarities of the cases after a cross-case analysis resulted in a framework, covering a path from an existing product, to the origin and diffusion of user technique innovation, to eventually subsequent user technique innovation-driven product innovation. This framework is compared with the traditional model of innovation – from a manufacturer’s perspective. Important in the new framework is the role of the focus of the user technique innovation, either a product-first or problem-first focus. Also, as mentioned in the framework, diffusion of the user technique innovation depends on the newness of the innovation and the social influence of the innovators and early adopters. Moreover, it became clear that for user technique innovation-driven product innovation to occur, an imaginary barrier needs to be crossed consisting of technological/legal allowance and market potential. Lastly, the user technique innovation-driven product innovation can occur twofold; direct product innovation from manufacturers, or first product innovation from users and subsequent manufacturer product innovation.

Introduction

In a traditional value system model, industry firms – either producers or manufacturers – obtain user input to develop and innovate products and services. These users can be intermediate users, who use the products as inputs to their production process, or end-consumer users, who use the products to satisfy their needs (Bogers, Afuah & Bastian, 2010). Professor Eric von Hippel of the Massachusetts Institute of Technology (MIT) was one of the first to observe the importance of user innovation – users, rather than manufacturers, are responsible for a large amount of innovation (von Hippel, 1986). User innovation is not restricted to one specific field or sector, multiple cases of user innovation covered in the literature originate from several backgrounds. For example, user innovation has been found in the field of medical equipment (Shaw, 1985), in the field of sports; more specifically kayaking (Hienert, von Hippel & Baldwin, 2006) and mountain biking (Lüthje, Herstatt & von Hippel, 2005), or in the field of cyber security (von Hippel & Paradiso, 2008). Important to state is the incentive difference between the industry firms and the users in innovation. Users expect to benefit from *using* a product or service they innovate, whereas industry firms expect to benefit from *selling* a product or a service they - directly or via user innovation – innovate (von Hippel, 2009). So, the incentive for innovation depends upon the relationship between the innovator and the innovation (Schweisfurth & Zaggl, 2016).

User innovation can occur twofold: product (or artifact) and process (or technique) innovation. Also, and under the scope of this research, technique innovation can provoke product innovation (Faulkner & Runde (2009)). Faulkner & Runde (2009) also mention that the importance of technique innovation by users in literature is neglected, where technique innovations are the changes in the use to which an existing object or tool is put. Neither is it possible to conclude from research how technique innovation can provoke product innovation. As a starting point, to provide a more specific definition of (user) technique innovation, Harhoff & Lakhani (2016) describe five summarizing aspects of the definition of (user) technique innovation:

1. New kind of activity/action (“new way of doing”).
2. Is executed by a person, either individually or within a firm.
3. Is a skillful, planned activity.

4. Either directly involves some physical equipment, or
5. is needed to operate/maneuver within an environment composed of specific artifacts.

Important to mention is that ‘specific artifacts’ denoted in point five, can be viewed as the objects or tools used. For example, a mountain biker using a new pedaling technique to improve his acceleration is connected to the artifact ‘mountain bike’. To better distinguish different types (or scenarios) of (user) innovation, in Figure 1 a framework from Hienert (2016) for different scenarios of user innovation is illustrated. The framework mentions the distinction between a technique or an artifact, and whether there is a product innovation with an existing technique (scenario C: new artifact, existing technique), technique innovation (scenario B: existing artifact, new technique), or a combination of both (scenario D: new artifact, new technique). Scenario A - referring to an existing artifact and technique - covers a scenario without novelty and innovation.

Due to the neglected role and limited coverage of user technique innovation in literature, part of this study is executed to bridge this gap by analyzing the origin and diffusion of user technique innovation in different cases (with a clear, existing artifact) where user technique innovation is utilized to satisfy users’ needs. Furthermore, these cases all include product innovation following the user technique innovation. The role of user technique innovation-driven product innovation will be analyzed in the pathway from an existing artifact to user technique innovation, to subsequent product innovation. The global aim of this study is to produce a framework after a cross-case analysis that shows this pathway, with special attention to the occurrence of user technique innovation and the relationship between user technique innovation and product innovation. To put this into perspective with the use of Figure 1, how does scenario B originate and how does this subsequently result in scenario D? To break up the research in parts, first, the origin of the user technique innovation will be analyzed in the cross-case analysis, thereafter the diffusion of this technique, and finally, the user technique innovation-driven product innovation will be explored. The analysis of these three components will result in the product of this research – the framework that will be mentioned and explained in the discussion and conclusions section.

Satisfying need or solving problem with:		Artifact	
		Existing	New
Technique	New	B	D
	Existing	A	C

Figure 1. Scenarios for novel techniques and artifacts (Hienerth, 2016)

Literature overview

In the Introduction is mentioned that the global aim of the research is to produce a framework that highlights the pathway from existing artifact to user technique innovation to subsequent product innovation. The origin and diffusion of user technique innovation and the relationship between user technique innovation and subsequent product innovation are under research. Within this scope centered around user technique innovation, previous (limited) literature on user technique innovation will be included in this chapter as a starting point for this research. First, the conclusions of the case study analysis in the field of medical devices of Hinsch, Stockstrom & Lüthje (2014). They mention in their article that user innovation in techniques triggers product innovation by users and manufacturers. Meaning that the user technique innovation can cause a situation where industry firms and users take the innovation a step further in the form of product innovation. Hinsch, Stockstrom & Lüthje (2014) mention the existence of this causal relation, technique innovation enabling product innovation in medical devices in their research.

Furthermore, Hinsch, Stockstrom & Lüthje (2014) mention that the diffusion of (new) techniques differs significantly from the diffusion of new products. This makes the reader believe that the process of user technique innovation differs from the (user) product innovation process. In a potential integrated model where user technique innovation enables product innovation to occur, it is essential to take the difference of diffusion of the two types of innovation into account.

Also, Faulkner & Runde (2009) state a proposition in their article on user technique innovation: “Users dominate manufacturers as sources of innovations in function (closely related to technique)”. The researchers argue that although manufacturers have close and lengthy engagements with the technological objects they produce, this is typically spread over a diverse set of activities – whereas users typically have a narrower and relatively more intimate engagement with existing objects’ use and function. Therefore, Faulkner & Runde (2009) mention that the scope of the

emergence of new uses or techniques for existing artifacts is likely to be far greater among users than manufacturers. Translating this statement to Figure 1, this means that scenario B is more likely to be caused by (end-)users than manufacturers according to the researchers.

Moreover, Schweisfurth, Raasch & Herstatt (2022) describe user technique innovation for end-users as ‘external users who come up with new process ideas’. This article states that this innovation is difficult to measure and is often not observable to others. Further investigation of (end-)user technique innovation in new cases is needed to better understand the process and origin of user technique innovation. Schweisfurth, Raasch & Herstatt (2022) also mention that new usage of techniques opens up opportunities for product and service innovation, the same is mentioned in Hinsch, Stockstrom & Lüthje (2014). One of the reasons is that technique innovation often involves existing artifacts being repurposed to fit new needs, but this can only be discovered if the user technique innovation becomes known to the big public. This can mean that significant market potential is needed before a user technique innovation can cause product innovation.

Lastly, in research about novel product uses in IKEA Hacks from Chan & Lim (2022), a distinction in user technique innovation is made based on either product-first or problem-first search. In a product-first search, the user first identifies a product (or existing artifact) to be ‘hacked’ for new purposes, whereas in a problem-first search, the user first defines a problem before hacking the product for new purposes Chan & Lim (2022). The researchers mention that the problem-first search leads to a greater number of successful technique innovations – since within the problem-first search users are less likely to face functional fixedness (users with a clear product in mind can be fixated on discovering potential uses), and users leverage greater awareness of problems that may not have readily adaptable solutions. One final remark is that the benefits of problem-first search compared with the product-first search are mitigated when the user has hacking experience (or experience in technique innovation). With experience, the innovative user is less exposed to functional fixedness Chan & Lim (2022). Through

this study, there will be an expansion of the current understanding of user technique innovation with new cases from different sectors covered and more focus on the origin and diffusion of the technique innovation. Next to this, as a result of this research, the framework mentioning the pathway from product to user technique innovation to user technique innovation-driven product innovation can be compared to the classical (manufacturing-based) innovation model. Differences between these models mention unique characteristics of the user technique innovation-driven product innovation model.

Research Methodology

This research will be conducted with the use of case studies, to eventually produce a framework after a cross-case analysis. In these novel case studies about user technique innovation, the origin of user technique innovations and subsequent (potential) product innovations are investigated. Generalizations of the individual cases in the cross-case analysis will eventually lead to the framework where a path from an existing artifact leads to user technique innovation to subsequent user technique innovation-driven product innovation. In Table 1 an overview of the selected cases with corresponding descriptions is provided. Three criteria were used to assess whether the cases are a good fit for the research to investigate the occurrence of technique innovation in the different cases:

1. *Novelty – not generally used (yet)*
2. *A concrete, clear description of both artifact and specific technique interest*
3. *Has to be a possibility to collect data – either interviews or archival data*

These three criteria are inspired by the five summarizing aspects – mentioned in the Introduction chapter – of (user) technique innovation from Harhoff & Lakhani (2016). It is important that the user technique innovation can be analyzed extensively, to conclude on the origin of the technique innovation and the role of the technique innovation on the emergence of product innovation. Included in Table 1 are the activity, the artifact connected, and the technique interests that describe the case, these components will be elaborated on in the individual case description. The data collection method is either interviews (Appendix A) or the use of archival data to best elaborate on the origin and the use of technique innovation in each case. The case study aims to produce a framework that illustrates the

process from an existing artifact - where new techniques or uses are discovered by users - to the emergence of product innovation. This framework results from first elaborating on the individual case analyses to eventually integrate recurring themes and findings in the framework. As inspiration for this framework, the interactive model of innovation mentioned in Rothwell and Zegveld (1985) is reviewed (Appendix B). This model shows the innovative process from a manufacturer's perspective – from idea to commercial product. Eventually, this research will produce a framework that starts with an existing artifact that via user technique innovation and product innovation eventually results in a (new) commercial product. Before the R&D phase in the model in Appendix B, for this research, first, the user technique innovation takes place. The framework, therefore, will be extended with processes connected to user technique innovation. In the cross-case analysis, the origin of the user technique innovation, the diffusion of the user technique innovation, and eventually the user technique innovation-driven product innovation will be the sections that will be elaborated on to create the renewed framework. In the individual case analysis, the cases will be investigated one by one to create an understanding of the user technique innovation and subsequent product innovation connected to each case. After an introduction of the cases in the individual case description, the user technique innovation and subsequent product innovation are explicitly mentioned for the understanding of the role of user technique innovation and subsequent product innovation in the individual case analysis.

Individual case description

Case I (Rowing)

Modern rowing as a competitive sport can be traced to the early 17th century. Rowing is the sport of racing boats using oars (attached to the boat). The oars are placed in the water and the rower applies pressure to the oars to generate a drive and move forward (*World Rowing*, n.d.). The existing artifacts under interest are the rowing boat, and especially the oars with the attached blades. Rowing is a very technical sport; therefore, multiple techniques are under interest to measure whether user technique innovation played a role in innovating respective techniques. For example, the usage of the oars in the water, body movement within the rowing boat, and specific adjustments to row in a multi-person rowing boat. The interviews need to provide insights into the

CASE STUDY	ACTIVITY	ARTIFACT	TECHNIQUE INTERESTS	DATA COLLECTION METHOD
I	Rowing	<ul style="list-style-type: none"> Rowing boat Oars 	<ul style="list-style-type: none"> Usage of oars in the water Body movement within the boat Positioning of the rowing boat within the water Specific adjustments within the boat (especially when rowing with multiple people) 	Three interviews with professionals
II	Padel	<ul style="list-style-type: none"> Padel racket Glass wall 	<ul style="list-style-type: none"> Usage of the padel racket (with the influence of tennis) Creating new shots in a relatively 'new sport' Usage of the glass wall on the court 	Three interviews with professionals
III	Multiple (<i>see Tech. interests</i>)	<ul style="list-style-type: none"> Cotton swab 	<ul style="list-style-type: none"> The versatility in the use of the cotton swab <ul style="list-style-type: none"> Cleaning infants' ears Make-up remover Medical purposes Construction of plastic model kits 	Archival data
IV	Filming	<ul style="list-style-type: none"> Go-Pro camera Camera accessories 	<ul style="list-style-type: none"> Usage of Go-pro camera for different purposes <ul style="list-style-type: none"> Sports (original purpose) Travelling Aerial Photography 	Archival data

Table 1: Brief Description of Case Studies

role user technique innovation played in rowing and how user technique innovation possibly resulted in product innovation. For this case, three professional rowers (anonymized to Rower X, Rower Y, and Rower Z) of the KNRB (Dutch rowing association) were interviewed to collect in-depth information on how user technique innovation and possible subsequent product innovation have played a role in rowing.

Case II (Padel)

Regarded as the fastest-growing sport in Europe, padel – a Mexican racket sport, with glass and fences demarcating the playing field, invented in 1969 – is becoming more famous daily (*History of Padel – Padel Academy*, n.d.). Despite the sports having similarities with tennis and squash, the sport has its own characteristics with the glass outside wall and especially the padel racket as existing artifacts under interest. Since it is a fast-growing relatively new sport, there is a lot of room for (user-technique) innovation. Some techniques under interest are the usage of the padel racket, the shots/smashes used in padel, and the usage of the glass wall on the court. The interviews are conducted to conclude on how user technique innovation has played a role in padel and whether this user technique innovation resulted in subsequent product innovation. To get insights with regard to technique innovation and product innovation in padel, three player-coach padelists

were interviewed (anonymized to Padeliste X, Padeliste Y, and Padeliste Z).

Case III (Go-Pro)

Founded in 2002 by Nick Woodman – a photo and video enthusiast – GoPro has grown into an innovative brand loved around the globe for its versatile and enabling products (*We Are GoPro*, n.d.). Woodman became motivated in 2002 during a surfing trip in Australia, where he was hoping to capture high-quality action photos, but could not because of the low quality of equipment at reasonable prices (Mac, 2013). Woodman's intentions, therefore, were to make GoPro – short for 'going pro,' Based on going professional in sport – the first affordable camera for action sports with appropriate quality. With the use of archival data for this case, the existing artifact, the Go-Pro camera, with its connected camera accessories will be explored. In the analysis, more uses/techniques for the camera will be researched to see how users found new purposes for the already existing Go-Pro camera. Thereafter, researching these new purposes will provide insights into possible product innovations that occurred to better serve the new purposes.

Case IV (Cotton swab)

The first mass production of the cotton swab already originated in 1923 by Polish-American Leo Gerstenzang. He came up with the idea after he saw

his wife attach wads of cotton to toothpicks to clean their infant's ears. The initial and only purpose of the first mass-produced cotton swabs was to clean the ear canal by removing earwax. In line with the story of the discovery of cotton swabs, the product received the initial name "Baby Gays" (The "Q" Stands for Quality!, n.d.). In the analysis of this case, the existing artifact, the cotton swab, will be explored with the use of archival data. Just as in the case of the Go-Pro camera, multiple new uses/techniques will be researched to conclude on the role of user technique innovation in this case. Thereafter, the research will conclude on the possible product innovations following the newly found purposes of the cotton swab by users.

Individual case analysis

Case I (Rowing)

Professional Rower X states that she had experimented with different rowing blades and grip on the oars. Already in the 1900s rowers and coaches wanted to align their technique(s) with the right materials. Different rowing blades were developed with their own characteristics – e.g., the difference between a stiff feel at the beginning of a drive with a fast-handling speed afterward in comparison with a clean entry with a stiff ending of the drive. But before the 1970s, manufacturers could not align their products with the different techniques used in rowing. Then came the innovations of the Dreissigacker brothers. Brothers Peter and Dick Dreissigacker – both Olympic rowers – were the first to experiment with carbon and fiberglass (weight reduction) and also the first to remodel the oar's blade. The brothers used their own equipment and sold them to fellow rowers, all witnessing speed increases (Innovations and Timelines, 2021). This example can be viewed as a product-first search, where the brothers Dreissigacker innovated the oars (after using them for years) to align them with the drive (their own technique) they used for rowing. Next to this with regard to the grip, Rower X states that to prevent blisters to occur, plastic handles were placed on the oars – with the downside that the handles become very slippery. Continuous development results in rowers demanding different materials to overcome the blisters and sliding handles. Rower X also mentions that experiments and tests with different oar lengths have been conducted over the years. Longer oars provide higher gear (heavier load) and an outcome to align the different rowers in a multi-person rowing boat.

Professionals Rower Y states that major innovations in rowing are held back by the WRF (World Rowing Federation) by its laws and

regulations. Large innovations could destroy the spirit of the sport according to the WRF. Therefore, possible new techniques and changes in the existing artifacts need to adhere to the laws and regulations. Also, Rower Y mentioned that he used a leaf-shaped blade to perceive greater grip at the start of the drive, but altered this to better row as a team, where identical blades result in the best result according to Rower Y. Rower Y also mentions that innovations are hold-back based on the market potential and conservativeness of the sport. In the seven to eight years he is connected to the KNRB, he saw a lot of (small) developments and innovations that disappeared after a while. Either because the innovations are just not connecting properly to the current technique or a lack of market potential. Lastly, Rower Y sees potential in the future for a rowing simulation where adjustments to existing techniques can be monitored. This is also useful for aligning teams to adjust to one another. More technique and product innovation could follow but with the high development costs he doubts whether this would be realized someday.

Professional Rower Z mentions that in Europe only two manufacturers of rowing boats exist, Filippi and Empacher. Empacher is the more long-lasting, sustainable – but also more expensive – boat. Due to a budget cap at the KNRB, only Filippi's are used. Potential improvements with Empacher boats cannot be discovered by the rowers due to this budget cap. Also, Rower Z mentions that the vision of the coach determines all the adjustments and materials used. Different adjustments in rowing result in different power levels (one drive becomes lighter or heavier). When the KNRB hires a different coach or coaches, the adjustments may be set at a totally different level. New techniques are needed to better align the technique with the adjustments of the coach. This limits the participation of the rowers in terms of adjustments and material. Lastly, Rower Z expects that most of the time savings in the future can be achieved by changes in the materials used. This can either come from pure product innovation, like improving the shape of the hull of the rowing boat, or from more efficiently aligning (new) techniques with (new) materials – to make the adjustments interpretation-free.

Case II (Padel)

Padeliste X mentions that transitioning from tennis to padel requires padelists to find a new playing style. Playing tennis at a high level before starting his padel career, Padeliste X found his first few months in the sport unnatural. He then mentions that most commonly, for about ten years now, three different-shaped padel rackets are used (round, diamond, and

teardrop-shaped). Before the innovation, only round-shaped padel rackets were used. Padeliste X mentions that some players of the sport started their own research and development to create new padel blade molds, that better fit different techniques. Some players are more attacking and need padel rackets that can generate more power, others need more precision with long shots. An example is Alberto Martín, an entrepreneur, and player, who led the development of the diamond-shaped racket with his company Saior (Saior Padel - Story, Innovation and Revolution, 2022). The diamond-shaped racket characteristics are high balance and a smaller sweet spot (the point that will give strikes the most power), ideal for players at the left side of the field that most commonly rush to the net, and players that want maximum power in volleys and smashes. The innovations in the shape of the padel racket can be seen as product-first searches, where (former-)players innovated the existing racket to better serve specific techniques in the sport. Also, Padeliste X mentions that with the increasing market for padel, a lot of people started their own racket brand (about six hundred). The fastest-growing sport in Europa also gets attention from large multinationals like Nike and Adidas which produce their own padel shoes and rackets.

Padeliste Y confirms that in a padel team consisting of two players, the left player most commonly makes the attacking smashes and volleys, and therefore the diamond-shape racket is the best fitting, whereas the right player is more tactical with high balls and hits from the backfield and a round or teardrop-shaped racket can be better fitting. Padeliste Y also mentions that he witnesses a 'new breed' of padel players that do not have a tennis background. This can result in players that are not biased by the playing style they used in tennis and the birth of new techniques and shots – especially with the growing number of players. Next to this Padeliste Y mentions that there have been innovations in the fencing and glass that surround the padel field, mostly after the improved performance of the players. To increase the speed and fluency of the game, part of the fences on the side have been replaced by glass (that allows the ball to bounce back in the field).

Padeliste Z nuances the quick innovations and rapid growth of padel and states the sport is still in its infancy. In the near future, a lot more innovations – both in technique as well as products like rackets, shoes, and walls – are expected by the former professional padeliste. This will be a result of the continuous growth in the coming years. As a practical example, Padeliste Z mentions that hybrid rackets (e.g., a combination of a teardrop and diamond-shaped racket) will be developed on a large

scale that better aligns with individual players' techniques. Furthermore, Padeliste Z mentions that some rackets are really expensive to purchase, depending on the brand, shape, and materials used. Padeliste Z expects that when more players get to play with the high-segment rackets, new techniques, and more product innovation will follow. Lastly, purely based on product innovation, Padeliste Z expects innovation based on geographical location. This can mean a canopy or dome above padel fields located outside as a remedy for the rainfall or innovations in materials used for the glass walls in padel. Hitherto, padel fields placed in residential areas cause a lot of nuisance. New materials must counter this nuisance.

Case III (Go-Pro)

Users of the Go-Pro camera saw the potential of new uses for an easy-to-carry, small, lightweight, and durable camera that can capture high-quality photos and videos in a variety of outdoor conditions. Therefore, the GoPro cameras were not only used for its initial purpose (action sports) but also in other activities such as traveling (Vannini & Stewart, 2016), aerial photography (Giones & Brem, 2017), and even lava field analysis (Pedersen et al., 2017). While the use of the GoPro camera for lava field analysis is a unique experiment, the camera usage in both traveling and aerial photography is a widely used interpretation of the originally labeled "action-sports camera" – with users all over the globe. Regarding the origin of the new uses of the GoPro in aerial photography and traveling, both can be viewed as problem-first searches. Both travelers, as well as users of drones, were looking for equipment with high resistance to record their activities. Both user groups found their solution in the already existing GoPro cameras.

All over the internet, videos from users using GoPro equipment in aerial photography and traveling were published. These new techniques of the GoPro camera in traveling and aerial photography initiated by end-users of the product ensured that the manufacturers at GoPro started thinking about reshaping their existing artifact. This is followed by easing the use with joined accessories that could be attached to the existing artifact with a changed surface or bundling the existing artifact with extensions for traveling and aerial photography. A totally different model than the initial GoPro camera, which included a clear case for the camera and a small but stable camera strap for usage in extreme sports. A practical example of the development of an attachment to ease the use of the GoPro in traveling is the "Volta grip," a grip that has a built-in battery that provides over four hours of recording time with

built-in tripod legs - ideal for traveling (Volta (External Battery Grip / Tripod / Remote) | GoPro, n.d.). The manufacturers bundled the Go-Pro camera with a drone, the “GoPro Karma Drone” for aerial photography. The usage of cameras on drones by end-users in combination with the promising drone industry opened new possibilities for the GoPro camera (Giones & Brem 2017). Witnessing new techniques and uses for their existing cameras, GoPro developed accessories and researched their existing artifact trying to benefit from new uses and explore the market for new users.

Case IV (Cotton swab)

Still most commonly used for cleaning the ear canal, users of the cotton swabs found other uses and techniques for the swabs. Already in the 1950s, Hollywood glamour recognized the potential of cotton swabs for applying and removing makeup (The “Q” Stands for Quality!, n.d.). Later, more uses and techniques from users of cotton swabs followed, such as medical purposes by doctors (Pang & Cheung, 2007; Schaudé et al., 2017) and uses in the construction of plastic model kits, for various applications such as painting and applying decals. For these mentioned new techniques, changes in the artifact were needed to better fit the purpose of the cotton swabs. Regarding the origin of the new uses and techniques for the cotton swabs, the new uses and techniques can be shown as problem-first searches. The cotton swabs enabled users to solve a problem or have a better product to fulfill an unconnected use, e.g. allowing make-up artists to finesse their work and providing an improved way to collect DNA (Pang & Cheung, 2007; Schaudé et al., 2017).

The traditional cotton swab has a single tip on a wooden handle, and these are still often used. Hitherto, multiple changes have been made to the cotton swabs to better serve the applications of the new uses and techniques. Changes in the different tip materials, the shape/design of the swab, the materials used for the shafts of the swabs (either aluminum, plastic, or wood), and the length of the shafts can be made to serve their own use (Zasada et al., 2020; COC, 2017). Zasada et al. (2020) mention that for different uses/techniques in healthcare, different commercially available tip materials are beneficial to use. The different tip materials have different chemical and physical characteristics, which can influence the specimen collection and release. In the research is concluded that swab composition and structure can have a significant impact on the collection and release of a sample. Also, with the great use of cotton swabs already since the 1950s, the cotton swabs developed to be the perfect fit for the

techniques needed for make-up artists. After the double-sided sterile cotton swab, both sides rounded, in 2011 the ‘precision tips’ were introduced with the cotton swabs being pointed at both ends to more precisely applicate makeup (Q-tips® Precision Tips™, 2016). Users of these types of cotton swabs recognized that they still used both rounded as well as pointed variants. Therefore, manufacturers came up with a solution, and double-sided cotton swabs pointed at one end and rounded at the other, became commercially available. Remarkable in this case is that the product innovation from the manufacturers came much later than the initial user technique innovation. The manufacturers did not find a way to better serve the new use or technique directly. Direct product innovation for the use of make-up only came 60 years after Hollywood glamour recognized the cotton swabs with the introduction of the ‘Precision Tips’. A lot of research and development was needed on the manufacturer side before the production innovation followed the technique innovation (The “Q” Stands for Quality!, n.d.).

Cross-case analysis

In order to identify patterns across the four cases, the four cases will be compared and contrasted in a cross-case analysis.

Origin of Techniques

All cases include one or multiple physical, clearly defined, existing artifact(s). In these cases, user groups came up with new techniques and uses for these existing artifacts. However, the incentives for the user groups are different. In Cases I and II, the user groups came up with new techniques and uses to serve them in getting better at the sport they already played. Whereas in Cases III and IV, the user groups found totally new uses outside the initial purpose of their corresponding founders. Connected is the difference in the origin of innovation in the four cases. Cases I and II are examples of product-first searches, the users have determined artifacts that they ‘hacked’ with new techniques to improve their skill in the sport. Cases III and IV are examples of problem-first searches, the users saw potential in new techniques and uses of existing artifacts to solve their problems and serve their needs. For these users, functional fixedness of the existing artifacts played no role in the technique innovation.

Furthermore, the technique innovations in Cases I and II originated from users that play the sport connected to the case. This means, for these product-first searches, the user group that potentially innovates using technique innovations, is fixed. The technique innovations mentioned in the case analyses

all became known by players of the sport. For Cases III and IV, this situation is different. The technique innovation enlarged and changed the users of the existing artifact, meaning that the user groups in these cases are not fixed. With a larger pool of users due to technique innovation, more users can further innovate techniques and eventually the existing artifact.

Another difference between the cases is the level of complexity and newness of the technique innovation. Cases I and II can be connected to more non-radical technique innovations with new techniques being found to serve the same purpose. In these cases, the users are familiar with the existing artifact and their purpose. For Cases III and IV, these cases are more radical technique innovations with new techniques found for an existing artifact to serve new purposes outside the manufacturer's initial purpose. In these cases, the users were not familiar with the existing artifact to serve its new purpose.

Diffusion of Techniques

The technique innovations under study have diffused to different degrees. One of the factors influencing the speed of diffusion is whether or not the new technique offers considerable use benefits to serve new purposes (radical innovation) or whether the new technique is just an addition to existing approaches (non-radical innovation). Cases III and IV diffused faster initially because these cases were not just merely an addition to many other approaches, but a radical technique innovation with a new artifact being used to better serve the purpose. For Cases I and II, a lot of different techniques with the same artifact were available to serve the purpose. The new techniques described in Cases I and II needed to be more efficient or effective to vanish the other techniques. This took longer, since the users innovators in Cases I and II, needed to prove with their own gameplay - and the gameplay of early adopters - that the technique is an improvement compared to the already existing techniques. After it became clear that the new techniques were dominant techniques - techniques that improved every user's game - the techniques diffused to all users. This concludes that the diffusion of techniques in Cases I and II was slow, but eventually, everybody used the new techniques, while the diffusion of techniques in Cases III and IV was fast, but not everybody in the initial user group started to work with the new techniques - not every GoPro user started to use the GoPro for aerial photography.

Another factor influencing the diffusion of the techniques is the role of the innovators. Hinsch, Stockstrom & Lüthje (2014) mention that the innovator(s) of the technique play(s) a key role in its

diffusion. The most important driver of diffusion is the personal contact with the technique under the supervision of someone already familiar with it. This makes the diffusion a much more social process and the diffusion depends on the ability of the innovators to convince other users about the improvement of the innovation. For Cases I and II, the social process was mostly connected to word-of-mouth advertising. The innovators and early adopters tried to convince the other users with their improved gameplay and other users and audience witnessing the new techniques could convince themselves and others to also benefit from using the new techniques. Innovators of the new techniques in Case III had a different advertisement machine, the internet. Innovators and early adopters uploaded videos all over the internet, which reached initial users and other people (who did not use the GoPro for its initial purpose) who also started using the new techniques. Due to the good and wide accessibility of the internet, a large audience saw the new techniques. Lastly, the diffusion of new techniques for the cotton swabs in Case IV was also connected to word-of-mouth advertising. The inventors' ability to convince the other (potential) users to use cotton swabs in the new techniques of make-up and plastic model kits, was filled in by letting other (potential) users know about the user benefits and showing them the improved results with the use of the cotton swabs.

User Technique Innovation-driven Product Innovation

The cases highlight multiple relations between the user technique innovation and the successive product innovation described. Two of the key drivers for letting product innovation arise after technique innovation are technological/legal allowance and market potential. In Cases III and IV, the manufacturers investigated the potential market for (new) users when innovating an existing artifact to align with the new technique. It is important to note that manufacturers' incentive is to benefit from *selling* a product they innovate. After the market seemed profitable, the manufacturers innovated the Go-Pro and cotton swabs. For Case III specifically, also the technological allowance was crucial to innovate on the cotton swab to better serve the new technique (make-up). Despite a large make-up market already being analyzed in the 1950s, not until 2011, the manufacturer came up with a product innovation. As explicitly stated in Case I, large innovations could destroy the spirit of the sport. The product innovations in these cases were bound by these prescribed laws and regulations. Cases I and II were less focused on market potential, since the users innovating the product were, as restated, trying to

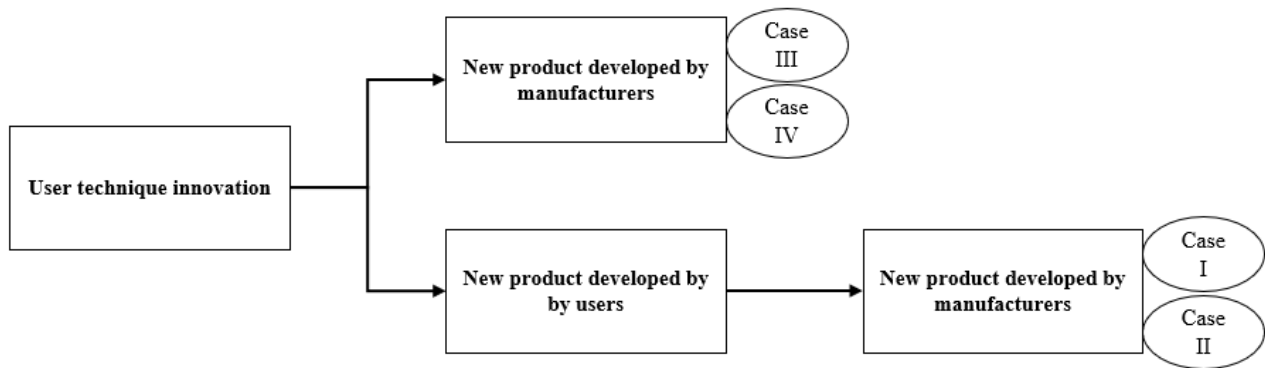


Figure 2: Impact of User Technique Innovation on Product Innovation

benefit from the innovation by *using* the product they innovated on. The incentive of the inventor was to directly improve the gameplay, instead of simultaneously benefitting from potential sales.

Another relation between the user technique innovation and subsequent product innovation is the direct impact of the user technique innovation on product innovation. In all four cases, new products are developed, but the stimulation of new products in the four cases is not equal. To show this, Figure 2 is introduced. After the user technique innovation in the cases, two mentioned trails can be walked. The first group to develop the product (either the manufacturers or the users) determines the length of this trail (Figure 2). In Cases III and IV, the manufacturers were solely responsible for product innovation. They saw potential in innovating a product based on a new technique and brought the product to the public – only the manufacturers innovated on the product. For Cases I and II, an extra step is included. After the technique innovation, the first users themselves went on to innovate on the existing artifact. Users innovated and developed new products, in these cases oars and padel rackets, to benefit from using them in combination with the new techniques. After the users started to successfully sell new products to a broad audience, the manufacturers saw the potential and executed research and development. In Cases III and IV, it became clear that large manufacturers jumped in the gap, whilst the initial user product innovators discovered and developed new products themselves. In these cases, it seems like the users executed preliminary work for larger manufacturers to join the market with their own products to better serve the new technique. The users enabled the manufacturers to confirm that there is a market for the new products. When comparing the two possible scenarios, the scenario with direct product development from manufacturers has more uncertainty. Despite the market research, the scenario where manufacturer development follows user development has more certainty because of the confirmed market potential.

Discussion and conclusions

The global aim of this study was to explore the pathway from an existing artifact to user technique innovation to user technique innovation-driven product innovation in a framework – with special attention to the occurrence and diffusion of the technique innovation. This framework (Figure 3) shows the origin of user technique innovation and its passage to subsequent product innovation. To better explain the framework, the three components ‘*Origin of Techniques*’, ‘*Diffusion of Techniques*’, and ‘*User Technique Innovation-driven Product Innovation*’ will be elaborated on based on the insights of the study and the framework. Thereafter, special attention will be made to the implications of the study and future research.

Origin of Techniques

New user technique innovation all starts with the drive of the user innovator(s) from a user group to benefit from using an existing artifact more efficiently or effectively, or for an existing artifact to better serve a new purpose. The potential user innovators from a group can be fixed - for instance, players of a sport that find new techniques to play the sport - but can also be dynamic if users find existing artifacts to use for new purposes. In comparison with the model in Appendix B from the study of Rothwell and Zegveld (1985), the idea in the new framework does not originate to eventually produce a commercial product initially. The idea (from users) in Figure 3 is in correspondence with the need to benefit from using the new technique. This can be benefitting from using an existing artifact for the same purpose in an improved manner or using an existing artifact to serve a totally new purpose. Therefore, the proposition:

P1: In comparison with the manufacturer-based model of innovation, the idea in the user technique innovation framework originates from

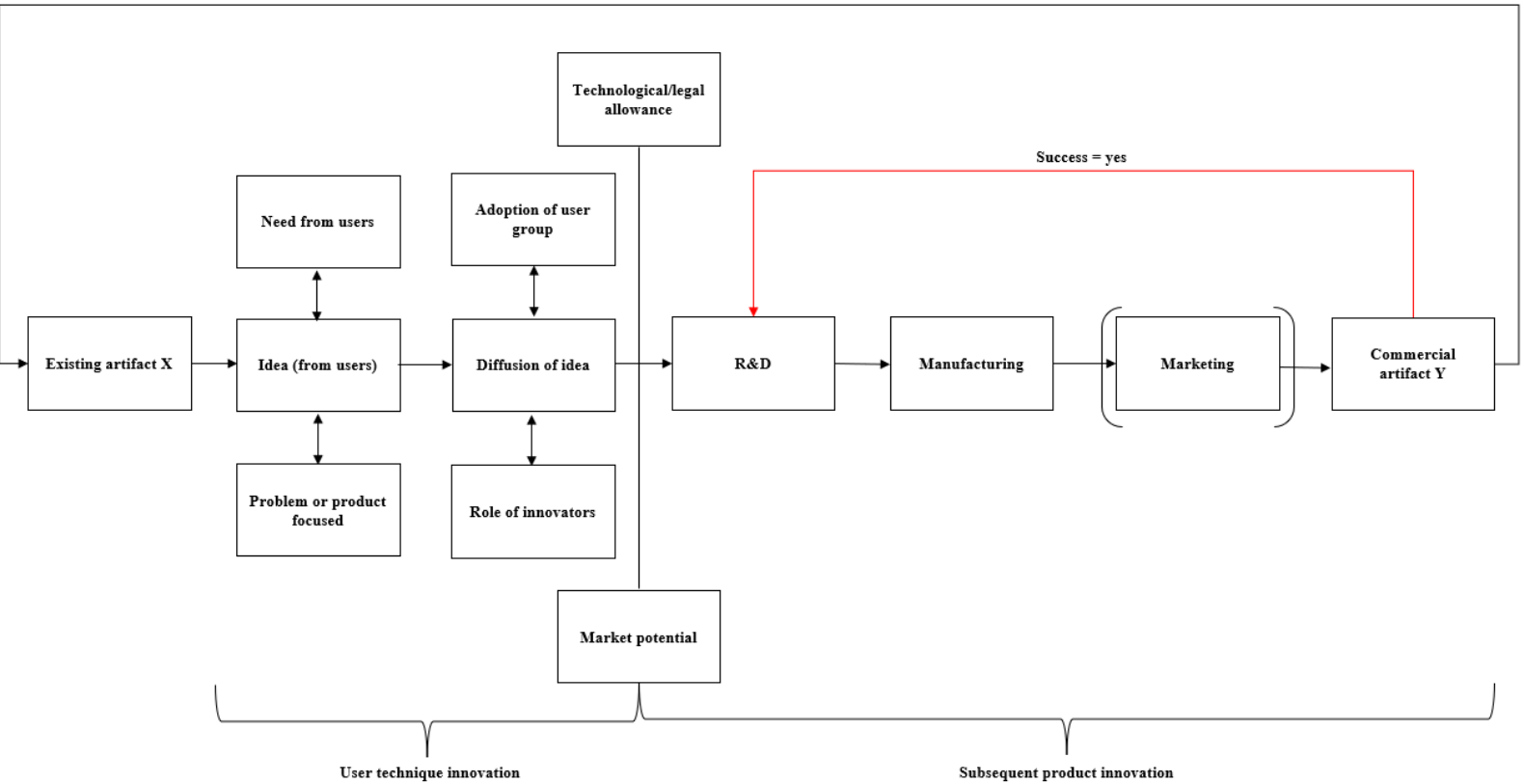


Figure 3: Framework including the Path from User Technique Innovation to Product Innovation

either a fixed or non-fixed user group not focused on a commercial product but trying to benefit from using this idea.

This is related to the initial focus of the innovation; this can be either a problem-first or product-first search. According to Cham & Lim (2022), the user first defines a problem before looking to innovate new techniques on an existing artifact in a problem-first search, whereas in a product-first search, the user first identifies the existing artifact to innovate on the defined artifact thereafter directly. Concluding, users search for ideas (in the form of new techniques) to benefit from using this new technique, where the incentive can be either an improved way to work with the artifact for the same purpose or using the artifact to better fulfill a whole new purpose. Therefore, the proposition:

P2: Users utilizing product-first searches, mostly search for an improved way to work with an existing artifact serving the same purpose. Whereas users utilizing problem-first searches, mostly explore an existing artifact to fulfill new purposes, where the existing artifact is identified after the problem.

Originating after the idea (from users) phase in Figure 3, is the user technique innovation. Subsequently, the diffusion of the technique starts.

Diffusion of Techniques

The diffusion of the new technique (denoted as diffusion of idea in Figure 3) is connected to the adoption of the user group. It became clear that the adoption depends on whether the technique is just an addition to many approaches, or whether the technique offers considerable use benefits to serve new purposes. In the sports cases, there were a lot of other techniques with the same artifact available. The new technique needed to show clear improvements to become adopted by the user group. Because this was not clear initially, the adoption started slowly. After it became clear that the new technique was dominant – faster than all others – every user in the user group copied the technique. When a new technique is found on an existing artifact to serve a new purpose, the users adapt faster. This is a result of the improvements immediately standing out more, due to the existing artifact being used for a new purpose. When using a new technique on an artifact that is not already used to serve a purpose, the benefit of using this existing artifact for the new purpose becomes known sooner. Therefore, the proposition:

P3: When different techniques to serve the same purpose on an existing artifact are available, the adoption of the user group starts slower than the adoption of a new technique on an existing artifact to serve a new purpose - slow diffusion. However, when

the technique becomes dominant, all users adopt the new technique.

Also, the user innovators play a great role in the diffusion of the technique innovation. The innovators need to convince other users from the user group about the improvement of the innovation. The user group can be convinced by the better results or gameplay that the user innovators realize but for the speed of diffusion, it is also largely a social process. With quick word-of-mouth advertising, or showing potential users the benefit of using the new technique on the internet, the chance of having more early adopters increases. Eventually, these early adopters can also show the benefits and advertise for the new technique to let the technique innovation diffuse even faster.

P4: User innovators and early adopters play a great role in the social process of the diffusion of a new technique. By quickly diffusing the new technique to (more) early adopters, the social process and diffusion increase with more visibility of improvements and benefits of the new technique.

User Technique Innovation-driven Product Innovation

To arise after user technique innovation, in this study, subsequent product innovation can have either one or two barriers in technological/legal allowance and/or the market potential of the product following the technique innovation. To better conclude on the specifics of this barrier, two separate scenarios based on the trails of Figure 2, the impact of user technique innovation on product innovation, will be elaborated on. One is the scenario with direct manufacturer product innovation and the second is the scenario where first users and subsequent manufacturers innovate on the existing artifact. Therefore, the proposition:

P5: User technique innovation-driven product innovation can occur twofold: either direct manufacturer innovation or first user- and thereafter manufacturer innovation. Both scenarios have their own technological/legal allowance and market potential barriers and pathway in the user technique innovation framework.

Scenario 1: direct manufacturer product innovation

For direct manufacturer product innovation to arise after user technique innovation, both technological/legal allowance, as well as market potential, must be acceptable. This means that before the R&D phase for a new product to better serve the user technique innovation starts, the technological

developments surrounding that new product must be available (e.g., knowledge about how to make sterile swabs for medical purposes) and the product and the product must have market potential. For the latter one, it is important for the manufacturer that there is a sufficient combination of both having a large user group as well as having a high adoption within this user group of the new technique to benefit from selling the product. If both factors are acceptable, Figure 3 shows the path from R&D to a commercial product as the interactive model of innovation in Appendix B describes. With a sufficient prototype, the manufacturers can start production and marketing to end up with a sellable commercial product. Eventually, this new product can also be innovated—users can come up with new uses and techniques for this commercial product as well. Therefore, the (new) commercial artifact Y in Figure 3 is connected to the existing artifact, which results in a continuous cycle.

Scenario 2: user and subsequent manufacturer product innovation

For this scenario, in comparison with Scenario 1, the barrier before product innovation is mostly concerned with the technological and legal allowance. For users to innovate on a product after user technique innovation, the market potential is less important – users want to benefit from using an innovated product after technique innovation. Whilst the technological developments surrounding the new product must be available just as in Scenario 1, the legal allowance also plays a great role in this scenario. Under this study, the sports cases analyzed both had strict regulations that must be followed. This can result in a limitation of the freedom that a product can be innovated on. The product innovation from users must adhere to these regulations. There are fewer requirements based on the size of the user group and the adoption of the user group in the diffusion of technique phase – due to the incentive of innovating the product to benefit from using it. After the barrier is crossed, again, the path mentioned in Appendix B from R&D to commercial product is walked. Only for the user product innovation, marketing is not always a standard step in the process, because there does not need to be a direct incentive to sell the product to the user group.

Now the second step, if the commercial product originated from user product innovation is a success – meaning there is a clear market for the new product – manufacturers step in to also get a piece of the pie. In Figure 3, this is highlighted with the red arrow sending the process back to the R&D phase, this time for the manufacturer. The manufacturer works out the steps, now with marketing to reach a greater audience, up until the commercial artifact.

Finally, on the new artifact, also user technique innovation can originate. The arrow from the new commercial product to the existing artifact results in a continuous cycle.

Implications and Future Research

This study makes several contributions to the user innovation literature and analyzed the influence of user technique innovation on subsequent product innovation. With the limited literature on user technique innovation and its role in the innovation model, this study provides a better understanding of the occurrence and diffusion of user technique innovation, and the subsequent steps to possible product innovation in comparison with the existing manufacturer's model of innovation.

New cases in the underexposed literature of user technique innovation are analyzed, from different backgrounds. First, in this study, it became clear that the innovative process starting with user technique innovation differs clearly from the already known interactive model of innovation (from the manufacturer's perspective). Two process steps are integrated into the framework, the innovative idea (or the new technique innovation) from the users and the diffusion of this idea. In this study, special attention is given to the fact that user technique innovation is not a fixed process. The user technique innovation idea is either connected to (a) a problem-first search or (b) a product-first search. It became known in this study, that the problem-first search was connected to cases where the existing artifact became used for new purposes. Also, for the diffusion of techniques, it became clear that innovators have a great role in the diffusion and that for the adoption of the user group also early adopters and whether the new technique offers considerable or in some cases dominant benefits are important factors.

Second, it became known that a barrier must be crossed for product innovation to arise after user technique innovation. Since the user innovators' initial purpose was to benefit from using the new technique, the path was not yet mapped out to a new commercial artifact. Two factors became known in this study – also integrated into the framework – (a) the market potential barrier and (b) the technological/legal allowance barrier. The direct influence of this barrier on the process and also the completion of the process denoted in the framework itself depends on the impact the user technique innovation had on product innovation. The study highlights two scenarios, (a) direct manufacturer product innovation and (b) first user and subsequent manufacturer product innovation. Which scenario is applicable also depends on the user technique innovation, with problem-first searches tending to

induce scenario a, whereas product-first searches are tending to induce scenario b. As is pointed out in the study, (user) technique innovations may also follow product innovations, therefore the framework resulted in a continuous process.

As for managerial implications, the framework produced in this research can help companies to better cope with user technique innovation. Earlier in the process, companies can detect user technique innovation and work around its characteristics. For example, if the user technique innovation is characterized by a product-first search, companies now know that the user group is more fixed than with a problem-first search. Also, with the insights of the framework, it can be said that manufacturers should involve themselves (earlier) in the diffusion of the techniques. If the manufacturers collaborate with the user innovator(s), the technique (and eventually the product) can get a lot more attention and early adopters which can be beneficial later in the process. Furthermore, the companies have more insights into the scenarios that can result after user technique innovation – the impact of user technique innovation on product innovation. If manufacturers want to start product innovation after user technique innovation, they can analyze which of the two scenarios is applicable and benefit from the characteristics described in this study.

For further research, it would also be interesting to assess the framework for complications resulting from non-success stories. Under this study, all cases included successfully adopted user technique innovation and all resulted in subsequent successful product innovations. To assess the validity of the framework, it would be interesting to see if more factors are barriers to successful product innovation after user technique innovation. Next to this, in this study, a clear distinction between the sports cases and non-sports cases could be found. It would be interesting to analyze other non-sports cases with product-first searches and subsequent direct manufacturer product innovation, to see if the process is equivalent or different in comparison with the sports cases under research.

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Appendices

Appendix A: interview appendices

Remark: the first three questions of the questionnaire – covering an introduction to the role of the participant within the sport - in Appendix A.1 are not included in the coding layouts of Appendix A.2 and Appendix A.3.

Appendix A.1: questionnaire research

Interview User Technique Innovation

Bedankt dat je tijd hebt gemaakt voor dit interview. Ik zal een korte toelichting geven hoe dit interview vormgegeven wordt. Het interview is een methode om data te verzamelen binnen mijn onderzoek omtrent “user technique innovation”. User technique innovation slaat terug op innovaties die gebruikers ontwikkelen door middel van het beoefenen van de sport of gebruiken van een product. Mijn scope van het interview is sport, met jouw invalshoek binnen *noem sport*. User technique innovation kent verschillende fases. Het begint bij het gebruik van een product of tool (*noem artifact van sport*), waarna de gebruikers of beoefenaars eigen methodieken of technieken gaan gebruiken of uit de omgeving zien. Dit kan uiteindelijk leiden tot een ontwikkeling in het gebruikte product of de gebruikte tool. Dit zal ik door middel van dit interview voor jouw situatie graag willen onderzoeken. Het interview is opgebouwd in 4 korte kopjes met 2-3 vragen. De kopjes zijn intro, bestaand product/tool, nieuwe techniek en mogelijk nieuw product/tool. Laten we gelijk beginnen met de eerste vraag.

Intro

1. Wat is jouw rol binnen de sport/welke functie beoefen je?
2. Hoeveel ervaring heb je binnen de sport (hoe lang draai je mee)?
3. Hoe was je eerste ervaring met de sport (was er sprake van ‘natuurtalent’)?

Existing technique and artifact

4. Zou je de basistechniek van de sport kunnen omschrijven (globale indruk)?
5. Zijn er verschillen in materieel waarmee de sport beoefend kan worden?

New Technique

6. Heb jij persoonlijke kenmerken (technieken/methodes) die jij hanteert binnen de sport?
7. Zijn er ook persoonlijke kenmerken die direct te maken hebben met het gebruik van het materieel?
8. Zie jij in je omgeving dat andere sporters persoonlijke kenmerken gebruiken of dat er nieuwe technieken binnen de sport ontstaan?

(Possible) new artifact

9. Worden bepaalde (nieuwe) technieken met een speciaal soort (nieuw) materieel gecombineerd (*alleen als op antwoord 5 “ja” is geantwoord*)?
10. Heb jij het gevoel dat bepaalde technieken en materieel binnen de sport verder ontwikkeld zullen worden?

Appendix A.2: coding layout rowing

Question	Theme	Open Code	Participant Response
Q4: Zou je de basistechniek van de sport kunnen omschrijven (globale indruk)?	Bekende technieken en materialen	Uitvoering basistechniek	Het is vooral met je benen. Veel mensen denken dat het met je armen is, maar voor de drive zet je voornamelijk af met de benen, waarna je een vloeiende beweging maakt met de bladen in het water.
	Bekende technieken en materialen	Doel basistechniek	Het doel is om zo snel mogelijk een boot in het water van A naar B te brengen, dat is eigenlijk altijd 2000 meter in een rechte lijn.
Q5: Zijn er verschillen in materieel waarmee de sport beoefend kan worden?	Bekende technieken en materialen	Bestaande materialen	In Europa worden twee grote merken gebruikt die met elkaar concurreren. Doordat een boot duur is en een limiet aan het budget zit, wordt alleen de goedkopere variant gebruikt en ontdekt.
	Bekende technieken en materialen	Bestaande materialen	De boten zijn van licht carbon materiaal met bladvormige bladen om de drive te maken. Laatstgenoemde is een uitvinding van twee voormalig roeiers.
	Bekende technieken en materialen	Bestaande materialen	Wij gebruiken bijna altijd wel hetzelfde (materiaal) maar af en toe wordt er met wat nieuws geëxperimenteerd, bijvoorbeeld andere bladen of kortere riemen.
Q6: Heb jij persoonlijke kenmerken (technieken/methodes) die jij hanteert binnen de sport?	Persoonlijke en nieuwe technieken	Persoonlijke technieken	Op het gebied van afstelling vind ik het belangrijk dat alles goed staat, weinig mensen houden zich daar erg mee bezig, maar ik vind het belangrijk dat alles afgesteld staat op mij als persoon.
	Persoonlijke en nieuwe technieken	Persoonlijke technieken	Ik beoefen verschillende drives in teamverband en persoonlijk om te achterhalen wat het beste resulteert in snelheid.
	Persoonlijke en nieuwe technieken	Persoonlijke technieken	Ik gebruik gemiddelde technieken, als er iets nieuws op het pad komt door de visie van de coach neem ik dit over.
Q7: Zijn er ook persoonlijke kenmerken die direct te maken hebben met het gebruik van het materieel?	Persoonlijke en nieuwe technieken	Relatie techniek/materiaal	De vorm van de bladen beïnvloedt ook de beste drive die erbij hoort, vormverschil in het blad maakt bijvoorbeeld de zwaarte van de drive anders.
	Persoonlijke en nieuwe technieken	Relatie techniek/materiaal	De visie van de coach is heel bepalend in de combinatie van techniek en materiaal, een nieuwe coach met een andere visie kan dit compleet veranderen.
	Persoonlijke en nieuwe technieken	Relatie techniek/materiaal	Ik gebruikte een bladvorm die meer grip had aan het begin van de haal, maar daar ben ik van afgestapt omdat je ook met mensen samen wilt roeien die dit niet gebruiken.

Q8: Zie jij in je omgeving dat andere sporters persoonlijke kenmerken gebruiken of dat er nieuwe technieken binnen de sport ontstaan?	Persoonlijke en nieuwe technieken	Nieuwe technieken uit omgeving	Ik zie andere sporters de riemen verschillend gebruiken (sommige roeiers gingen over op plastic handvatten, wat blaren voorkomt maar wel zorgt voor gladdere riemen).
	Persoonlijke en nieuwe technieken	Werkwijze nieuwe technieken	Vaak zie ik dat één iemand uit de ploeg in contact komt met de coach om te spreken over de techniek die de coach voor ogen heeft. Niet iedereen is druk met de technieken (en materieel) die toegepast wordt.
	Persoonlijke en nieuwe technieken	Nieuwe technieken uit omgeving	Roeiers en vooral ook ex-roeiers zijn erg bezig om voor zichzelf een combinatie van techniek en conditie te vinden die het roeien maximaliseren, dit kan soms lastig zijn in een meerpersoneelboot om synchroon te roeien.
	Persoonlijke en nieuwe technieken	Werkwijze nieuwe technieken	Binnen de bond wordt veel getest met riemlengten om roeiers met verschillende lengten beter met elkaar te laten roeien en testen of langere riemen – die zwaarder roeien – sporters beter maakt.
Q9: Worden bepaalde (nieuwe) technieken met een speciaal soort (nieuw) materieel gecombineerd?	Relatie nieuwe techniek met nieuw materiaal	Productinnovatie na nieuwe techniek	Je ziet vaker dat in deze meer conservatieve sport dat er o.b.v. nieuwe technieken nieuwe materialen komen die getest worden, waar je vervolgens weinig van terugziet.
	Relatie nieuwe techniek met nieuw materiaal	Productinnovatie na nieuwe techniek	Nieuwe technieken op bestaande riemen resulteerde in nieuwe riemen en nieuwe riemen in nieuwe technieken.
	Relatie nieuwe techniek met nieuw materiaal	Bewustwording potentie productinnovatie	Er wordt continu gekeken of ontwikkelingen in de sport gecombineerd kunnen worden met beter materieel.
Q10: Heb jij het gevoel dat bepaalde technieken en materieel binnen de sport verder ontwikkeld zullen worden?	Toekomst	Belemmering ontwikkelingen	Ontwikkelingen worden beperkt door de regel- en wetgeving van de WRF die de ziel van de sport wil behouden. Ook gaan ontwikkelingen trager doordat het een kleinere conservatieve sport is.
	Toekomst	Vernieuwingen in de sport	Ik denk dat er zeker nog ontwikkelingen zullen komen, voornamelijk in de materialen gebruikt voor de boot en riemen. Dit zou vervolgens ervoor kunnen zorgen dat dit materieel beter gebruikt kan worden met nieuwe technieken
	Toekomst	Vernieuwingen in de sport	Simulaties hebben in het roeien ook potentie. Persoonlijke bijenschappen aan een goede roeitechniek zou roeiers sneller op professioneel niveau kunnen brengen.

Appendix A.3: coding layout padel

Question	Theme	Open Code	Participant Response
Q4: Zou je de basistechniek van de sport kunnen omschrijven (globale indruk)?	Bekende technieken en materialen	Uitvoering basistechniek	Als voormalig tennisser waren de eerste maanden in het padel onwennig, vooral het afleren om hard te slaan. Padel heeft veel weg van tennis maar inhoudelijk was er veel te leren.
	Bekende technieken en materialen	Doel basistechniek	Punten scoren door middel van het gebruik van het veld als bij tennis, waarbij je ook de glazen en hekken om het veld heen kunt gebruiken om de bal terug in het veld te krijgen.
	Bekende technieken en materialen	Mondiale verschillen	Als je naar landen als Spanje en Argentinië kijkt, is de sport al jaar en dag groot. In Nederland valt nog veel te leren gezien de jeugdigheid van de sport.
Q5: Zijn er verschillen in materieel waarmee de sport beoefend kan worden?	Bekende technieken en materialen	Bestaande materialen	Voorheen had je één racket, een ronde massief racket met gaten, maar in één materiaal te verkrijgen. De afgelopen 10 jaar zijn er ronde-, druppel- en diamantvormige rackets gekomen door (ex-)spelers.
	Bekende technieken en materialen	Bestaande materialen	In padel zijn de ballen erg belangrijk. Het liefst zal je ze elke keer willen vervangen, maar dat loopt natuurlijk op in de kosten.
	Bekende technieken en materialen	Bestaande materialen	De meer ervaren spelers kiezen voor een druppel- of diamantvormige racket, waar de beginners eerder voor een rondvormig racket zullen gaan, dit is een ontwikkeling van de laatste jaren doordat het padel zich ontwikkeld heeft.
Q6: Heb jij persoonlijke kenmerken (technieken/methodes) die jij hanteert binnen de sport?	Persoonlijke en nieuwe technieken	Persoonlijke technieken	Padel wordt met twee spelers gespeeld en de linker speler slaat meestal de aanvallende volleys, waar de rechterspelers meer de controleur met lange halen is.
	Persoonlijke en nieuwe technieken	Persoonlijke technieken	Voorheen was ik meer aan het rennen naar het net, maar door beter in staat te zijn invulling te geven als rechterspeler, is mijn spel vooruitgegaan.
	Persoonlijke en nieuwe technieken	Persoonlijke technieken	In mijn lessen en tijdens de wedstrijden probeer ik soms nieuwe slagen te bedenken of uit te testen, meestal neem ik hetgeen wat ik uit de wedstrijden leer mee naar de trainingen.
Q7: Zijn er ook persoonlijke kenmerken die direct te maken hebben met het gebruik van het materieel?	Persoonlijke en nieuwe technieken	Relatie techniek/materiaal	Ik zie veel linker veldspelers gebruikmaken van een diamantvormig racket, hier is het 'sweet spot' kleiner en het balans hoger waardoor je meer kracht kan krijgen bij slagen.

	Persoonlijke en nieuwe technieken	Relatie techniek/materiaal	Als rechter veldspeler ben ik me meer bewust geworden van mijn rol en gebruik gaan maken van een druppelvormig racket die qua eigenschappen het beste bij mij past.
	Persoonlijke en nieuwe technieken	Relatie techniek/materiaal	Ik ben een speler die gemiddeld gezien meer gebruik maakt van het glas om hier een stuk beter in te worden.
Q8: Zie jij in je omgeving dat andere sporters persoonlijke kenmerken gebruiken of dat er nieuwe technieken binnen de sport ontstaan?	Persoonlijke en nieuwe technieken	Nieuwe technieken uit omgeving	Spelers worden steeds beter met het gebruik van de nieuwe vormen, daarnaast komen er ook veel hybride vormen (mix tussen rond/druppel/diamant) op de markt.
	Persoonlijke en nieuwe technieken	Nieuwe technieken uit omgeving	Ik train een van de eerste lichte spelers uit Nederland die niet eerder getennist hebben, dit kan resulteren in een betere padel techniek doordat ze niet beïnvloed zijn door een eerdere tennis techniek.
	Persoonlijke en nieuwe technieken	Ontwikkeling algeheel niveau	Aangezien padel nog steeds een jonge sport is voor grote delen van Europa, is er op de velden een steeds hoger niveau te zien, waarbij soms ook nieuwe slagen naar voren komen.
Q9: Worden bepaalde (nieuwe) technieken met een speciaal soort (nieuw) materieel gecombineerd?	Relatie nieuwe techniek met nieuw materiaal	Productinnovatie na nieuwe techniek	Spelers, vooral op professioneel niveau, krijgen steeds meer de kans om hun techniek en speelwijze te koppelen aan een hybride racket.
	Relatie nieuwe techniek met nieuw materiaal	Vergrootte productinnovatie	De trend is dat een groot aantal spelers hun techniek/speelwijze steeds beter kunnen matchen met hun racket, waarbij spelers ook hun eigen merk opzetten.
	Relatie nieuwe techniek met nieuw materiaal	Productinnovatie na nieuwe techniek	Door de groei van de sport zullen steeds meer spelers met hun eigen technieken komen, waardoor ook grote multinationals als Nike en Adidas dit nauwlettend in de gaten houden voor nieuwe producten.
	Relatie nieuwe techniek met nieuw materiaal	Productinnovatie na nieuwe techniek	Doordat het spel sneller is geworden, is een deel van het hekwerk vervangen door glas om de bal langer in het spel te houden.
Q10: Heb jij het gevoel dat bepaalde technieken en materieel binnen de sport verder ontwikkeld zullen worden?	Toekomst	Potentie van de sport	De innovaties in padel staan nog maar in de kinderschoenen, zowel het spel zelf als het materieel zal de komende periode nog flink geïnnoveerd worden.
	Toekomst	Vernieuwingen in de sport	Als spelers meer met hogere segment rackets gaan spelen, zullen meer nieuwe technieken en productinnovaties volgen
	Toekomst	Vernieuwingen in de sport	Een afdekking boven het veld kan een uitkomst bieden om het veld bespeelbaar te houden in landen met veel regen. Ook wordt er gekeken naar nieuw materiaal voor het glas om geluidsoverlast tegen te gaan.

Appendix B: an interactive model of innovation - manufacturer's perspective

