

Research Article

# Assessment of Design Values in Designing Product Standards: A Design Study on a Sport PPE

Lisa Giusti Gestri\* 

Future Building Initiative (FBI), Monash Art, Design and Architecture (MADA), Monash University, Melbourne (VIC), Australia

## Abstract

Participation in sports requires using Personal Protective Equipment (PPE) to preserve athletes' well-being. Although equipment may negatively impact performance, governing bodies often impose standards on participants subject to their jurisdiction. Although the vast majority of new products are incremental innovations, radical innovation still attracts design researchers' and professionals' attention. The design of complex systems needs the expertise of various kinds: designers are fundamental in conceiving innovations in response to developing ways of product use and customer needs, despite they must face product standards, which often act against product innovation. Despite product innovations benefiting consumers in many markets, they do not necessarily benefit consumers in sports PPE markets. In this paper, the author reflects on an ethnographic case study and the importance of the involvement of end and co-dependent users in the design of sports PPE. For this study, the design of the Australian safety vests for jockeys, frequently overlooked, was examined for incremental innovation and its relationship with its standards. This was inspiring to consider an assessment of design values in designing product standards in the sports field. As co-design is increasingly applied across multiple sectors, there is a huge need for practical design guides to support product development and co-designing with users. Further research in this field is highly recommended.

## Keywords

User-Centered Design, Sports Protective Equipment, Product Standards, Design Innovation, Product Innovation, Design Values

## 1. Introduction

Information systems and the latest technologies transform our world: consequently, the attention to integrating moral values into the conception, design, and development of emerging technologies became increasingly significant [1]. Besides, direct attention should be given to the value aims and assumptions of a particular design. Innovation possesses a pivotal role in enhancing product performance and customer benefits: thus, designers are those playing a key role in conceiving and actioning innovations in answer to developing

conditions of use and customer needs. Following the COVID-19 pandemic, people's lifestyles and habits have changed: particularly, the healthcare system is now almost forced to provide services in everyone's houses [2]. Therefore, technology stepped up with a more crucial role in supporting those needs with the aim of improving both the quality of life and the safety of all the patients and caregivers. For a while, and especially for those researching the design of health products, there has been the necessity of User Centered De-

\*Corresponding author: [Lisa.GiustiGestri@monash.edu](mailto:Lisa.GiustiGestri@monash.edu) (Lisa Giusti Gestri)

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sign (UCD) to address even secondary and tertiary users as well. [3-5]. Although that, a clear definition of secondary and tertiary users is still missing and often is nuanced by primary users in terms of the significance of their input and access role. Although that, a clear definition of secondary and tertiary users is still missing and often is nuanced by primary users in terms of the significance of their input and access role. Nevertheless, wearable technology products (e.g., sports activity trackers and smartwatches) have become significantly important and used in our lives: their popularity has grown, and their generated data may be applied to help health professionals offer better quality treatments to their patients in many fields.

In sports, to preserve athletes' safety during their activities, Personal Protective Equipment (PPE) is still the best answer. However, because each sport has a diverse nature the PPE literature argues ways in which design innovation and advanced materials now available have been utilized to protect athletes from injury. This was experienced by the author during her investigation on sports PPE specifically, the Australian jockeys' safety vests in use show a lack of product standards' innovation. Specifically, being a jockey is a risky profession and their safety vests should save their lives by reducing the severe or avoiding the injuries experienced, for instance, if a fall occurs. Consequently, the author strongly recommends further research for the ongoing scope for new designs to be introduced to this market: thanks to the advanced materials and wearable technologies well spread into sports and associated with enhanced functionality and design, even jockeys may receive benefits by applying those to their safety vests with the aim of improving their wellbeing and reduce jockeys' recovery time in case of falls or other accidents.

When there are these product challenges and thus opportunities, often the market applies incremental innovation to gradually bring improvements and refinements to an existing product or decides to bring radical innovation when a product needs enhancement or upgrades. Despite being riskier, radical innovation may bring greater benefits. However, either incremental or radical product innovations aren't currently possible in the field of the Australian jockeys' safety vests due to the constraining effects of their product Australian standards, which have been merely and rarely revised in the past decades. Hence, this paper discusses the findings from the first Australian case study, conducted by the author, that involved for the first time and simultaneously, jockeys and health professionals. This allowed the author to demonstrate the importance of product standards, which generated the idea of transforming safety vests into wearable technology to bring benefits to both jockeys and related medical professionals, and the importance of design values and product standards in this field too. [6]. There is a need for this because current safety vests are still failing to provide a superior level of protection and thus, integrating the latest technology may lead to reducing jockeys' injuries and recovery time.

## 2. A Brief Overview to Explain Why Product Standards Are Core

The safety standards applied to PPE in sports are set by the government, national health, and public health organizations to identify risks and protective equipment needed in those sports with a particular action or high-contact sports (e.g., football, hockey, or horse riding) to decrease the risk of injury. Accordingly, PPE for high-impact sports may include products like helmets, protective eyewear, body protectors, mouth guards, face protection, jock straps, protective footwear, elbow and/or knee pads, and padded flame-resistant pressure suits for those participating in motorcycling and motocross. Occupational safety and health standards protect the athletes who professionally compete or as part of their employment. However, the whole product standards field is like a jungle due to the variety of standards applicable by the nations: notably, the majority of multinational firms apply private standards to control production processes and international supply chains, which globally have a value of about 80% of global trade [7, 8].

The World Trade Organization (WTO) and the European Union (EU) decided to adopt two different agreements on product standards. The WTO's approach is mainly based on a National Treatment (NT) principle, while the EU's approach relies on Mutual Recognition (MR). Standards are forced for levels of externalities but resulting too high under MR and too low under NT: this leads to prefer NT when the trade in goods' amount featured by high levels of externalities is large [9]. However, independently of the nature of externalities, both NT and MR do not reproduce the optimal complete contract. Indeed, NT performs better for goods showing high levels of externalities, while MR is suitable for goods characterized by low levels of externalities.

Product standards receive much attention because products must meet specific requirements to be allowed for sale in a given country. The most popular international agreements are the NT and the MR: the NT is a non-discrimination requirement because enforcing those product standards used on foreign firms should be no stricter than those applied to domestic firms [10]. Consequently, country heterogeneity in the design is core because products with a sufficiently high or low level of consumption externality need harmonizing standards for global optimality: therefore, country heterogeneity has relevant implications for the desirability of alternative kinds of product standards.

The WTO categorized standards into three wide categories: compatibility standards that are applied to complementary products to facilitate the exploitation of network externalities; environmental standards with the scope of reducing (negative) environmental externalities; and safety standards used in cases of information asymmetry between producers and consumers [9]. Nonetheless, private standards may be a threat to governments in negotiating international agreements regulating standard setting as Berti and Falvey point out "official"

*international standards could be overridden by stricter 'unofficial' private standards"* [11] (p. 866). Still, each government is involved in product standard setting to some degree: however, most of the product standards are notionally voluntary standards determined by the private sector and thus, they became de facto compulsory. Besides, a product standard is a specification or group of specifications regarding a product's attributes [12]. Standards usually come from the cooperation of firms, occasionally in partnership with the government: nevertheless, conformity with standards is voluntary [13].

The author identified the major international industry that provides clothing and equipment for horse riders as an interesting case to investigate what motivates product development however, it is often overridden. Particularly, designing PPE for equestrians offers significant challenges, as per jockeys' safety vests. In 2011, an Australian report dedicated to the analysis of injuries and risk factors experienced by jockeys raised significant concerns and doubts about the validity of their product standards. [14]. In addition, Giusti Gestri and Barnes also identified the supplementary problem of a lack of alignment *"between standards for products that interact during use as well as the challenge of adapting international standards to reflect local conditions such as climate and turf conditions in the case of safety vests for jockeys"* [15] (p. 849).

### 3. Users: Who Are They

Every day, mankind is confronted with the design, development, and use, of (new) technologies that in some way impact upon them [1]. Our fast-changing world is characterized by strong competition and the complexity of products and processes consequently, what is meaningful today may quickly change before tomorrow. Focusing only on solutions leads to results that can solve issues that in the meantime have already become meaningless. Accordingly, if the aim is to bring a successful product to the market, multiple criteria should be considered but these are fundamental: strong process development, fast production, and perfect timing of market entrance. [16]. Consequently, the process of bringing a new product or service to the market is called New Product Development (NPD) because once an opportunity is identified, a fresh design should be developed and applied to the new product then, this might become available for sale but if only exclusively satisfies users' needs and wants [17, 18]. In this way, the acknowledgement of users' needs plays a core role in designing a product's success during its innovation process: obtaining knowledge about users' needs is essential in creating a successful product or service, tangible or intangible does not make any difference. Hence, product innovation means a novel product that is completely different from the previous ones. The new product would be appreciated because of its new aesthetics and/or functions, which make it dynamic and context-dependent, and highly adjustable to our fast-changing

world [19].

Even in the sports fields, products can be viewed in terms of their appeal, with product feelings rising from users' emotions or previous negative experiences about a particular product. Users are the individuals who will interact and utilize the final product introduced on the market but, at the same time, are those with needs and expectations as per the role and value of design in NPD, which has been reinforced through the years [20-24]. It is a fact that success requires the design of the direction of your innovation journey before designing a solution because there is a significant need to push innovation to what is meaningful [25]. It is almost impossible to reach product innovation without design at the center of this process, even in the unique effective kind of innovation strategy when technological breakthroughs merge with the radical innovation of meanings. However, one of the biggest challenges remains how to stimulate users to purchase that product/service and offer them positive experiences and meanings: having a unique and provocative design may awaken emotions but even costs should be considered because users may not be satisfied with those innovative features offering some new benefits to justify costs and enhance their experiences [26, 27]. Applying the relationship between design research and technological research leads to developing the right product by targeting the users' needs. This reinforces the necessity to investigate how social values may be affected by practices of design materialized in emerging technologies and explore how design practices may stimulate ethical reflection and action [28].

Given that technology-push and design-driven innovation are tightly linked, design is core to developing a new product, but users are often believed to be passive adopters of technology instead, users should have an active mode in product development because are the people capable of creating new meaning through the wearable interface often possessed by the products [29]. Users are keen on positively accepting innovative products only if they can elaborate on the new, such as materials or shapes because the aesthetic quality evaluation is based on the context [30]. Nevertheless, there are still products like the one investigated in the Australian case study (jockeys' safety vests) where the standards used seem to be an obstacle to product innovation and users are not involved in its design development.

#### 3.1. Design and Innovation: Their Pivotal Role in Designing for, With, and by Users

Design is a pivotal characteristic of what it is to be human and Heskett clearly defines it as *"an essential determinant of the quality of life"* because it impacts every aspect of our daily life, whether it would be a good or a bad design [1] (Chapter 1, p. 2). Good design doesn't necessarily mean an attractive product: a good product possesses a good design if it can communicate pleasure through its users' experience. Thus, to generate a successful product, empathy should be the essence

of design because is the best way to comprehend what users see, experience, feel and listen to. However, it is necessary to take into consideration even users' contexts, habits, fears, and relationships: only with this adroitness, can designers contribute to understanding the hidden users' needs and thus progress their experiences by realizing a tailored product or service. According to Mehalik and Gorman, we must "*go out toward people to inhabit their worlds, not just by rational calculations, but also in imagination, feeling, and expression*" [32] (p. 306). Thus, good design and positive experiences help users in making decisions but even advertising may influence the first choice by priming customers [33].

The notion of *design* encloses a complex concept and has received various nuances over time: therefore, its basis, we can state it is located to express the work of an artist. More precisely, only those industrial products having an aesthetic intent in the design stage may be associated with the design category [34]. A product's external appearance is relevant but still not everything because its shape possesses meaning too: a mix of integrating, coordinating, and articulating the product's functional and technical-constructive factors along with symbolic and cultural factors contribute to its success [35]. Thus, good design means a balance between aesthetics and accessibility. In the sports equipment field, the combination of materials and design is crucial to satisfy athletes' needs and support their performance. Consequently, the preferred materials are those able to achieve the combination of properties completely and readily in the necessary shapes and/or designs.

In the case of sports PPE, their design must perfectly interact with the athletes while using these products strongly: things like force transfer and vibrations to users, whose soft tissue may experience damage and/or injury at strains should be considered and based on the sport analyzed. Thinking of young athletes because of their age, their sports PPE proceeds by adapting the adult equipment to them via scaling it down. However, this may negatively impact them because young athletes are constantly and fast growing. As it should happen even in the horse racing industry, users should be considered as individuals instead of being grouped into age, gender, and height categories: designers and manufacturers should seriously consider customized options to satisfy users' needs and not only group them based on size, strength, gender, and ability. Nonetheless, users give importance to a product's aesthetics, and this often persuades them of the product's ease of application. Notwithstanding, users are human beings and each of them interacts with a product and situation in its way, also considering the diverse requirements, that are based on everyone's situations and skills experienced.

Designers should listen to users to produce an innovative and winning design by providing access to a product for as many users as possible to achieve inclusive design too. The identification of users' needs is salient because allows companies to develop products that last in the marketplace. A designer may demonstrate empathy in listening to users'

needs because each of them has different goals while using a product. These goals reveal the information requirements that should be addressed to obtain a high level of usability. It is fundamental to recognize the importance of UCD perspectives in providing powerful methods to understand how users attribute meaning to existing products because their innovation is based on two strategies: outcomes enabled by breakthrough technologies, and improved product solutions that are driven by an adequate analysis of users' needs [36]. Nowadays, innovation is trendy and pivotal due to the first factor at play in product innovation is radical innovation driven by technology, while the other is incremental innovation that is pulled by the market.

Summarizing, the industrial design process may be defined as a problem-solving process by drives innovation with the result of an improved quality of life via advanced product and user experiences. Without invention and creativity, innovation is not possible however, only by utilizing both, the creation of new products and services may be reached. [37]. Designers choose to innovate products radically or incrementally and evidence from firms that utilize product innovation varies across countries due to the product standards in use, but this may block innovation, as in the Australian case study about safety vests for jockeys. Accordingly, designers are the secret weapon in the development of products showing innovation but also able to accommodate users' needs and occasionally challenge product standards to achieve a good and successful product design.

### 3.2. Empathy Through Design Thinking

As stated, we live in a fast-changing world where technologies are widely spread but many applications still experience difficulties in gaining exposure because not well developed due to the old knowledge that often settles and is isolated within a specific field consequently, impacting new knowledge in gaining exposure. Designers able to empathize with users are better capable of fitting in inclusive design for users with special conditions within the design process and generating mainstream products that are desirable, pleasurable, and satisfying for everyone to use [38]. However, the focus on only users' day-to-day life experiences and their desires leads to a Human-Centered Design (HCD) process to interpret users' emotions and becomes a problem-solving tool [39].

Nevertheless, there is a need for usability design because pleasure and usability are together: the emotions experienced by users while interacting with a product help them to act in a certain way rather than in other ways [40]. This reinforces the importance of the bond between human and environmental factors: it is a complex and dynamic link, affected by factors such as cultural, social, institutional, and historical context. Indeed, Cato states that the framework should acknowledge what a designer expects users to do and that what they do is often different because every user is unique: however, the

framework may be applied to understand the final product's value and its success [41]. The product ecology framework affirms its pivotal role in understanding users' needs and consequently generating a product with good design: it was core to the author's case study because takes inspiration from the connection between human and environmental interactions to conceal the boundaries while relying on social ecology theory to understand how products evoke social behaviour [42, 43]. It is well-known that aesthetic pleasure, emotional pleasure, and symbolic meaning are part of every user's experience. Particularly, symbolic meaning is based on memory retrieval and association, support for identity (self-expression of status), beliefs about the kinds of users who utilize the product, support for user values and social relatedness. Thus, each user experience with a product and/or service has its own ecology and mediated dynamic factors consequently, the users bring previous experiences, emotions, and expectations into product interaction [44].

A product is capable of conveying meanings, but these are different for each user, based on different times, and also in a diverse context. Accordingly, the author opted for a research design applied to product ecology with a theoretical framework to amplify the sense of what a product is and what it could be for a range of diverse users [42]. Specifically, the author took inspiration from Forlizzi's theoretical framework for this case study, which supported her in understanding how a product may evoke social conduct but also offered a way to choose the appropriate research methods and expand the design culture in interaction design that enables design-centered research. The daily use of a product generates unique meanings and feelings for each user due to this everyday utilization, which often leads to a long-established product standard.

## 4. Methods and Findings

Some years ago, the author investigated a niche sports PPE product (safety vests for jockeys) via an ethnographic method, in the Australian context, and from the users' point of view. She considered how the relationship between user and product is influenced by the context within which it is situated consequently, the author investigated the safety vests for jockeys, along with focusing on their users, and their product standards because too many pressures are still restricting their design evolution. Consequently, inspired by Harte et al. in defining User Experience Design (UXD) as *“the perceptions and responses of users that result from their experience of using a product or service”* [45] (p. 2), the author enforced that in her case study aiming to identify the whole group of users that may impact the development of the safety vests' design.

In this field, design has a key role in the development and/or implementation of safety vests' innovation. During the literature review, the author identified a significant number of publications discussing on what is the right sample size and saturation to be identified as appropriate in qualitative and

also quantitative research [46-50]. Therefore, the author preferred the saturation definition as a *“matter of degree and it should be more concerned with reaching the point where it becomes “counter-productive” and that “the new” is discovered does not necessarily add anything to the overall story, model, theory, or framework”* [52] (p. 136). Consequently, the author acted as the research investigator of a product from the point of view of its users because she considered the relationship between the users and the product but also how this one may be impacted by the context within which it was located while determining a design framework. Along with that, Marshall et al. (2013) describe three methods to contribute to the sample size applicable in qualitative research with the following guidance:

*“... (a) grounded theory qualitative studies should generally include between 20 and 30 interviews; (b) single case studies should generally contain 15 to 30 interviews; (c) qualitative researchers should examine the expectations of their intended journal outlets based on history and culture; and (d) replication studies should further examine the impacts of culture and study design [46] (p. 21)”*

As a result, the author considered her overall number of 20 participants as satisfying due to the aforementioned points (a), (b), and (c). Still, saturation was reached because her sample dimension relied on a multiple number of factors and also because when interviews are utilized, it is normally achieved in a homogeneous participant group between 13 and 15 participants [52]. For this case study, the author preferred the case study methodology which is usually applied to focus on a small or to collect data about a small sample but on a specific topic. However, a researcher's subjectivity may be at risk during research design due to biases and thus, the author decided to apply multiple data collection methods with the aim of accepting the trustworthiness and validity of data gathered from various participants, which were comparable and substantial [53]. Consequently, because the author utilized a qualitative research method, her case study started with a desk research project to identify and summarize the design of safety vests' history and their eventual evolution from both academic and industry perspectives. This initial work supported her in identifying and elucidating the users' needs along with the Australian horse racing industry's insights. This phase was pivotal in helping the author during the data collection stages, particularly during the conversations with the participants.

Subsequently, the participants were chosen among jockeys (professionals, apprentices, and retired) who were primarily based in Melbourne (VIC, Australia) and riding in flat races organized only in the metro area, as well as related local medical professionals. Once the overall group of participants was completed, the author began with the first phase of data gathering: the individual semi-structured interviews. These happened between July and November 2016, intending to identify users' needs and thoughts on safety vests for jockeys. Although a list of standardized questions to be utilized during

the interviews was prepared by the author, she often utilized them as a prompt only to guarantee the discussion of specific points. However, the participants always had the opportunity to make unstructured contributions because of the chosen method of semi-structured interviews. At the end of the semi-structured interviews stage, she began a preliminary analysis of the data collected with the aid of the NVivo software to test their results' trustworthiness. These initial findings advised the conduct of a focus group, which was the next data collection phase [54, 55].

The focus group was conducted in October 2016 and organized to familiarly share insights on the participants' experiences with their safety vests. Because both the author and the participants already have started to know each other from the previous data collection phases, thanks to this established relationship, the author could run the focus group in a suitable and comfortable atmosphere for all the participants: consequently, both parties embraced the freedom to give voice to their deep feelings and opinions [38]. The main purpose of collecting data was to gather a deep understanding of the design context and the users' experiences with the jockeys' safety vests: recognizing what the users really need and want is crucial in design research. This was reached via the semi-structured interviews, the focus group, and the observation phase: thanks to that, the author was capable of establishing a deep engagement with users' emotional attachments to their belongings. Specifically, the majority of the observation was conducted at Victoria's Apprentices School and during the fitness sessions at Exercise Research Australia (ERA). The author could record the observation phase thanks to notes and some photographs.

This case study had an overall number of participants equal to 20: specifically, 6 apprentice jockeys, 9 fully qualified jockeys, and 2 former jockeys, plus 2 doctors and 1 intensive care paramedic. Among the jockeys, 16 of the 17 participants had experienced at least one significant fall during their whole career but when they wore their safety vests. Instead, the medical professionals reported having significant experience in treating jockeys' injuries due to falls, impact with the barriers, or horse kicks along with having a long history of attending the racecourses with the ambulances during race days.

Before beginning any data collection stages, a subcommittee of Swinburne University of Technology's Human Research Ethics Committee (SHESC) approved the study. The whole group of participants reported English as their first language, along with being aged 18 plus, and all gender were welcomed. Significantly, the author accepted the participants who had not been diagnosed with anxiety, depression, or any other emotional disturbance in the 12 months before the data collection phases. These criteria led the author to meticulously select the best and most appropriate participants who met the scope of her case study. In addition, following the written informed consent received to participate in this study, the participants' privacy has always been guaranteed by using codes rather than their names. Among the jockeys, a distinc-

tion is possible between those with less experienced horse riders, who had a more neutral response to the design of the safety vests currently used. Instead, those jockeys with more horse riding experiences reported more reluctant insights in appreciating the safety vests because they rode before and after they became compulsory along with their both national and international riding experiences.

#### 4.1. Learning from the Users About Thoroughbred Horse Racing

Horse riding is well acknowledged as a dangerous but popular occupation, regardless of jockeys' and horses' skills and training, it is not possible to foresee falls. Specifically, a past New Zealand study reports an overall incidence rate of 23.7 hospitalizations per 100,000 persons per year and an overall death rate of 0.17 per 100,000 persons per annum [56]. Consequently, horse riders are considered exposed to higher danger levels than motorcyclists and, as stated by Paix, Australian horse racing faces an injury incidence per event involved in eventing competitions of 0.88% exceeding the motorcycle injury incidence which was 0.24% for motorcycle racing [57]. Along with that, the injuries experienced by horse riders have a global impact in terms of cost to the public health system. For instance, the overall cost of consultation and treatment per accident in Sweden is of €1,400 per hospitalized patient, while in New Zealand the average cost per horse's fall is NZ\$ 3,000. Instead, the insurance claims cost among licensed jockeys, track riders, and stable helpers was AU \$6 million per annum almost more than a decade ago [58]. It is a fact that injuries reported by horse riders are a significant and constant public health concern consequently, the safety vests for jockeys became mandatory to be worn in 1998 as compulsory PPE. To date, horse racing is a major worldwide industry with a long history. In Australia, horse racing began in 1788 and by the 1830s it was a popular sport thus, the first official horse race was held in Sydney's Hyde Park by the 73<sup>rd</sup> Regiment in October 1810 [59]. Nowadays, horse racing means a mix of adrenaline, the rush of speed and a thirsty feeling for being the winner. For a jockey, racing on a country track or at a major city meeting does not make any difference: being the first to cross the final line is all that matters, especially during the last phases of a horse race, when jockeys reach a significant speed and push the horses at their limits. The more they win, the quicker jockeys are back to the saddle day after day, putting their lives at risk each time. Hence, the author analyzed and investigated if and how jockeys' safety vests may be redesigned to enhance their protection from injuries experienced by jockeys and that can be linked to accidents in professional racehorse riding or daily trackwork.

From the beginning, a sense of astonishment, because someone (the author) was interested in their experiences with safety vests, was well shared with her along with surprised feelings in discussing the constraining effects of their product standards. Specifically, participants from the horseracing

industry made comments that they had often tried to share their feedback and comments about the safety vests but had been ignored. At the same time, they showed enthusiasm about sharing their stories with the author about their falls, injuries, and discomfort while wearing the vests, along with their perceptions of the limitations of current products. Particularly, the jockeys demonstrated a strong sense of consciousness that their profession is extremely risky and mainly attributed the feelings of restriction when wearing a vest to a system that almost has always ignored their concerns or not ever involved them in the development of standards for vest design.

Freedom is core to jockeys in as much as they must bend their head, turn to look around for other horses coming, talk to each other during races and even be able to roll into a ball in the case of a nosedive fall – an ordinary way of tumble where jockeys may be flung forward into the turf. Hence, the standards in use seem to create issues for jockeys rather than provide protection even through a more updated vest design. This study also had participants from the medical sector, who confirmed the beneficial effects to jockeys of having compulsory safety vests since 1998 however, they also recognized that their design has limitations. Specifically, these thoughts originated from many years spent on the jockeys' side at the racecourses, helping them during critical injuries times, which need to quickly act and make fast decisions such as removing or not removing the jockeys' vests when they are lying on the ground. Jockeys were the most critical and unsatisfied about the knowledge of those who established and maintained the safety vests' standards. Specifically, jockeys with more years of experience have been the most critical because they had experienced the issues with the vests for the longest time thus, without any changes. One participant complained that "*I don't know how they do the standards [J04]*" while another one reinforced this by commenting "*I am not convinced the standards are right [J03]*".

Overall, the vests were experienced as uncomfortable to wear due to their rigidity and felt hot and even heavy. Therefore, the absence of ergonomics due to not specification of the product standards was perfectly shared by the female jockeys, asking for a softer and more flexible vest to accommodate their body shapes. With the application of the UCD approach that supports the development of products and solutions via the involvement of human perspectives (users) in each step of the UCD process, designers may consider the desires, wants, and needs of the users to satisfy those at two diverse levels: functional and emotional [60]. Those observing the design of health products have mentioned, for a decent amount of time, the need for UCD to recognize secondary and tertiary users but without making them the same as primary users in terms of the significance of their input and access role [61-63].

Thus, the author reckoned jockeys as the primary users of the safety vests in directly utilizing the product. However, the medical staff couldn't be categorized as secondary users be-

cause they immediately deal with the safety vests but also couldn't be called tertiary users because they are not the decision-makers in purchasing these products. Consequently, the author called them dependent-based users and she suggested an extension to the traditional UX and UCD models is worthy of further research since, in cases such as this, a class of user might exist that is neither a secondary nor tertiary user, not a stakeholder, but rather a co-dependent user group. Hence, she designed a conceptual framework to be utilized when a dependent class of users is present, and in which the success of a product design relies not only on qualitative engagement with the user or user persona (e.g., the UX model), or with a particular human user at the center (e.g., the UCD model) but is co-dependent on the equal engagement of a critical co-dependent user. The author has chosen the name Dependency-based User Experience (D-UX) for her suggested framework. As per the safety vests for jockeys, both users and secondary, and co-dependent users rely on the same product standards, which still to date are stopping innovation, and that may address their needs. Accordingly, the author suggests future research in this field but also other design research to test the concept of a co-dependent class of users within the general UX model for special product contexts.

## 4.2. Method

This Australian case study highlighted that being a jockey is a distinctive and risky occupation but sports PPE like safety vests for jockeys might help to save their lives [6]. The author combined the data gathered and those detected from documents and then ordered into larger topics: the inductive data analysis was useful in producing meaning from the data and built significant theory from practice [64, 65]. This way of theory building suited this study very well and the findings were shown as problems, propositions, and guidelines.

The data analysis particularly saw the collected semi-structured interviews and the focus group data being classified into text and audio. Subsequently, the audio data were transcribed into text while the interview questions and transcriptions were reviewed to obtain an overview understanding of the data collected. Specifically, the analysis of the text was run as a proxy for experience instead, the transcript as text had an analysis conducted via thematic, which produced generic themes. Taking into consideration that the use of thematic analysis (TA) helps further with the framework and the data gathered coding, the author used TA to support her study due to its nature and the non-academic participants involved [66]. Moreover, with a strong focus on the users, the author acted as a qualitative researcher who utilized the par-

ticipants' points of view to obtain broader themes and produce a theory interconnecting them.

Notably, to avoid or reduce the introduction of biases in the data-gathering stages and analysis, the author opted for the application of multiple methods and sources of data, intending to build a holistic, objective, and reliable overview of a case study of users in practice. Consequently, she preferred data triangulation to produce robust findings: mixing data types helped her validate the claims that may arise from an initial feasibility study but via the application of multiple methods of data collection (in this case, individual semi-structured interview, focus group, and observation) the author established rigorous findings due to the data triangulation reinforced the validity and the growth of utility.

## 5. Results and Discussion

It is a fact that since the early 2000s, the Australian safety vests' standards (ARB 1.1998 and the European Standard EN 13158) are still in use but have not been significantly updated to provide a more innovative design and higher protection for the users. The absence of innovation is the primary obstacle to the product standards in the field of jockeys' safety vests because the standards maintain a traditional approach. Product standard stimulates designers in all fields to consider end-user participation as a characteristic of progressive design practice.

In the design process, design values are the basis of the formation of design principles: they are the qualities and characteristics designers want to embody in the product that they are designing. They compile the essence of the product, determined by what creates its success and what differentiates it from its competitors. Creating design values is a process of determining what is important about a product and its users.

Despite the various government's efforts in applying product standards, a domestic standard regarding an international standard is not always protectionist but rather can be the opposite, implicitly subsidizing imports [67]. It is worth mentioning that the majority of participant jockeys reported having encountered problems because the safety vests came into contact with their helmets during horse riding, bringing the issue of standards interaction under the spotlight. Many manufacturers of jockeys' helmets do not possess or have the intention of having relationships with those producing their safety vests: notably, helmet standards do not take into consideration those used for safety vests.

Thus, by focusing on safety or environmental externality and trade, domestic and international contexts can affect the provision of a product's environment/safety through a standard. In this Australian study, this issue was particularly experienced because despite countries having diverse characteristics and the fact that it is almost impossible to standardize the horses' tracks, often the jockeys' safety vests must comply with the same standards, and this may compromise jockeys' safety. Moreover, there is no official document about a pro-

fessional definition of safety vests for jockeys and this causes misunderstanding, almost forcing the manufacturers to produce products with a traditional design: this excludes innovation in terms of materials and the latest technological applications because the standards are yet not updated to accommodate them.

## 6. Conclusion

It is well stated the benefits produced by the use of analytics in sports medicine, which are supporting in monitoring and forecasting the athletes' activities, especially those data gathered via wearable technology have a significant clinical impact. Despite that, there are sports fields where these benefits are barely applied. This study highlighted that being a jockey is a risky and unique profession, but the current Australian safety vests are still unable to avoid or reduce jockeys' injuries. Thus, because wearable technologies and advanced materials are now well spread among sports, even the field of safety vests for jockeys needs innovation to enhance the function and experience of safety vests. The author, via her qualitative study, requested that research-informed design should include jockeys and medical professionals as the core, not only to re-design these products but also to perform as a catalyst for the revision of safety vests' standards in ways that are dynamic and context-specific.

As substantially described in this paper, because of the safety vest standards in place in Australia, neither incremental nor radical product innovation is possible in this field. Since their introduction in 1998, the safety vest standards have been marginally reviewed and this impacts the safety vests' performances in offering a high level of safety to jockeys. Instead, changes like design variations or new templates to revise the neck cut (both front and back of the vest to avoid interaction with their helmets) may benefit jockeys by offering a better level of protection and comfort. Only in this way, users' needs be satisfied along with creating a new scenario where the standards can be revised to also evaluate related standards for the safety vests and helmets for jockeys.

Designers may have the power to challenge the *status quo* of a product along with its standards: this allows them to consider multiple users (e.g., primary, secondary, co-dependent) that still rely on the same product design. These benefits may apply to various sports PPE: along with that, this challenge can even lead to the application of the latest materials and technologies to products to offer ergonomics and innovation benefits to the users. Specifically, the introduction of innovation and ergonomics applied to the safety vests for jockeys would support its development and can convert them into a wearable tech vest: this generates benefits for the jockeys and even for the medical staff, which can provide a quicker and more accurate aid and track the medical history of injured jockeys. Due to the injuries' similarities, jockeys, horse riders and those involved in other high-impact sports (e.g., hockey, skiing, motorcycling) may

obtain benefits from the author's findings.

Being able to provide a serviceable and functional product design along with constant standards revision may guarantee the consideration of both users and co-dependent users and even more certainty in solving their needs. For this specific case study, the opportunities for incremental improvement can address the basic and rigid design; lack of ergonomics; the paucity of advanced materials and technologies; protection to the spinal area; absence of a UCD approach to enhance marketability and provide alternative designs for male and female users; reduce the conflicts between the safety vest and helmet due to diverse both standards and designs in use. Instead, a radical innovation approach provides the chance to create whole new products and markets: it could be the answer to address the majority of the issues attributed to safety vests from the participants as the present-day designs enabled by the standards in use may be compromised to be sufficiently altered.

Competition between products and prices is generated by international product standardization, which usually reduces trade flows. Consequently, product standards should be revised, and the author sees at least two avenues for future work on studying designing for incremental innovation in this field. One avenue requires an urgent revision of safety vests' standards to allow product innovation, while the other is the inclusion of dependency users in the design development. In addition, the knowledge produced by this Australian case study may contribute to smart vest blueprints and sports PPE, and even provide foundations for future directions in design research.

## Abbreviations

PPE: Personal Protective Equipment  
 UCD: User-Centered Design  
 WTO: World Trade Organization  
 EU: European Union  
 NT: National Treatment  
 MR: Mutual Recognition  
 NPD: New Product Development  
 HCD: Human-Centered Design  
 UXD: User Experience Design  
 ERA: Exercise Research Australia  
 SHESC: Swinburne Human research Ethics Committee  
 D-UX: Dependency-based User Experience  
 TA: Thematic Analysis  
 ARB: Australian Racing Board

## Author Contributions

Lisa Giusti Gestri is the sole author. The author read and approved the final manuscript.

## Conflicts of Interest

The author declares no conflicts of interest.

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