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Towards a Multi-Perspective Based Ontology to Develop Smart Wearables for Paediatric Habilitation

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Abstract. A user-centred approach is applied during the design process of rehabilitation devices to eventually make therapy more efficient and effective. Similarly, this applies to the development of Smart WEarables for Paediatric Habilitation (SWEPH), which are utilised by children with physical limitations. Additive Manufacturing (AM) provides design engineers with a multitude of possibilities, especially the ability to attain more personalised devices which meet the individualistic needs of diverse users. Nevertheless, the more user-centric a device is, the more complex the design and AM requirements become, making it more difficult for the designers to satisfy the different needs of the users. In this study, the user groups considered are the children with physical limitations, the occupational therapists and the parents of the children. These users bring various requirements that the designers must abide by, to achieve a positive User eXperience (UX). Given the challenge to design SWEPH which provides a high-quality UX, this paper proposes a multi-perspective-based ontology that takes into consideration the following three aspects: a) requirements of multiple users and other significant stakeholders b) UX measures of the three different users of SWEPH and c) Design for Additive Manufacturing (DfAM) considerations. Ultimately, this ontology aims to facilitate the design of SWEPH and assist design engineers in developing optimal devices with a higher acceptance rate and user adherence, whilst taking advantage of the benefits AM offers. Future work proposed is aimed to confirm the uncertain links established in this ontology and eventually verify and validate it holistically to guarantee its practicality and applicability.

Keywords: design assistance; design for additive manufacturing; user experience
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1 INTRODUCTION

Smart wearables are becoming frequently used during therapy to help individuals rehabilitate more effectively. Such devices are worn by individuals with physical limitations and used during rehabilitation exercises to support the therapist deliver more efficient sessions. The functionality of these smart devices varies from assisting motion, in order to help users gain full functionality of their limbs, or to capture motion for interacting with a serious game (designed for purposes such as teaching, with entertainment as their by-products). In this study, the latter type is considered, which are aimed purposely for children with physical limitations to habilitate their upper limbs. These devices are worn during the child's daily habilitation exercises routine, for motivation purposes to make home-based therapy more interactive and ultimately more effective. It is important to note that habilitation differs from rehabilitation, as it is mostly targeted towards children to acquire new functional abilities, rather than to regain their functional skills.

Although smart devices seem to be the ideal way to perform better during therapy, studies have shown that similar devices have a rather high rejection rate. It is calculated that around 50-56% of the individuals who have different needs, refuse to use body-worn devices and assistive technologies, with even approximately 15% of these artefacts never being used [16] [27]. Papp et al. emphasise that to decrease the rejection rate of these devices, User eXperience (UX) needs to be implemented during the design process [33]. ISO 9241:2010 defines UX as the "*person's perceptions and responses resulting from the use and/or anticipated use of a product, system or service*" [18]. Although various other definitions exist, UX is still considered a rather abstract construct.

In habilitation, user needs vary from one child to another, each having different functional goals [11]. This makes it essential to go for a more tailor-made device, instead of off-the-shelf, to meet their individualistic needs. Bespoke devices can be achieved via Additive Manufacturing (AM) as it is a manufacturing process, which if exploited well (e.g., by maximising the build envelope), can potentially be suitable for mass customisation. As AM differs from conventional processes, the Design for Additive Manufacturing (DfAM) tool was developed to help design engineers take advantage of the benefits AM offers and hence reach its full potential [39]. DfAM guides these designers to think differently from when designing products for conventional processes. For example, one DfAM rule entails avoiding features which require support structures to manufacture to reduce build time and post-processing, as well as obtaining a better surface finish. Thus, DfAM is a suitable tool for design engineers, to optimally develop bespoke habilitation devices for AM and ultimately meet the users' needs.

Furthermore, UX is not only dependent on the design of the physical device (the product) but comprises the service system as well, which the users interact with [26]. Typically, upper limb habilitation devices form part of a product-service-system (PSS), which consists of transferring the motion captured, via the embedded sensors, into a peripheral device used to display the serious game. Extended reality is being implemented to further immerse the user in the game and enhance their experience when making use of the habilitation device. However, the focus of this study will be on the physical wearable device of the PSS and the users' experience when they interact with it.

To determine the users' requirements for Smart WEarables for Paediatric Habilitation (SWEPH, two separate qualitative studies were conducted with the potential users, including children with physical limitations, occupational therapists and the children's parents, as well as with design engineers and technical experts. The insights and desires of these stakeholders were noted to help develop a PSS which satisfies their needs. These studies portrayed an extensive and complex holistic view of the requirements and UX aspects to design SWEPH fabricated with AM, which are intended to interact with a serious game [3-4].

As ontologies are used as systematic knowledge-sharing tools, this paper proposes a preliminary multi-perspective-based ontology, including the following characteristics: a) the requirements of multiple stakeholders of SWEPH b) UX elements of the three user classes of SWEPH devices and c) DfAM considerations to take advantage of the benefits AM offers.

The following section reviews the state-of-the-art ontologies related to product, service or system user interaction, leading to the identification of the research gap which will be addressed in this paper. Section 3 describes the methodology adopted to achieve the multi-perspective-based ontology, taking into account the outcomes of the studies previously conducted [3-4], together with requirements found in literature. Subsequently, the ontology is presented in Section 4, followed by a discussion in Section 5, to identify future work to complete the ontology proposed. Ultimately conclusions are drawn in Section 6.

2 REVIEW ON ONTOLOGIES

Reasons for generating ontologies for product development include; involving a number of designers as part of the development of products, for a greater diversity of requirements and features, for a greater variety of particular purpose products, finding solutions, or reducing the cycle of manufacture by decreasing the initial stage of the product's lifecycle [36]. In this study, the focus is placed on developing a knowledge-sharing tool based on the requirements of multiple SWEPH stakeholders. To achieve this, literature was reviewed on knowledge-sharing ontologies, specifically on medical products or services, emphasising on (re)habilitation.

The development process of medical products and services needs to consider stakeholders and their requirements, with an emphasis on quality and risks. Santos et al. depicted a graphic representation of a medical device development process by highlighting the general requirements every medical device must abide by, regarding its effectiveness, safety and quality [38]. Hagedorn adopted user-centred design (UCD) approach to present a detailed model of engineering design, combining customer requirements with concepts of ergonomics, usability and user environment [15]. This model is presented via an ontology, showing a hierarchy of user requirements and design elements which are required to implement a UCD approach in medical devices. Hagedorn furthered on this study by including the aspect of AM in the development of medical devices [14]. The ontology was used as a supporting tool to address existing challenges of medical device design, utilising DfAM tool for optimisation and consolidation of parts, the process and its parameters selection, as well as broad design rules, for instance, minimum feature size to ensure parts will print successfully. However, Hagedorn's work overlooks the impacts the DfAM tool has, on the users of medical devices and the respective experience they undergo when interacting with such artefacts.

Gullà et al. defined a user-product ontology to search for products according to the users' needs. Instead of a knowledge-sharing tool, the ontology functioned more as a search engine to guide customers to look for the products or services they desired based on the characteristics and needs they have inputted [13]. They presented this by creating two separate ontologies, one for the product and one for the user, and followed a two-step method to connect the user's characteristics and goals to the product/service categories and specifications [13]. A more goal-specific ontology was proposed by Karim et al., targeted toward users with special needs [23]. Karim et al. used semantic web technology to systemically map the information between the user interface and its users (the individuals with impairments). Conversely, Bowen et al. used ontologies to present the effects of the environment or physical location on the usability of interactive medical devices, including factors which are detrimental to the ease, speed and cognition of the medical devices' performance [6].

Annamalai et al. presented a comprehensive PSS ontology of generic devices, encompassing stakeholders, PSS design, customer needs, use phase and product life cycle, amongst other root concepts [1]. One of the aims of developing this ontology was to build a platform for the stakeholders within the PSS to be able to interconnect more effectively and share ideas amongst themselves with less ambiguity. Similarly, Morán et al. proposed a PSS ontology, aimed at the development of Virtual Environments for Upper Limb Motor Rehabilitation (VEULMoR), taking into account different stakeholders' inputs and the patient rehabilitation progress when interacting with virtual reality technology [29]. The ontology proposed was evaluated based on its usability and importance to facilitate communication between key stakeholders. VEULMoR supports the design of virtual environments for upper limb motor rehabilitation, especially to avoid overlooking any key factors.

Evaluation is an important stage during the generation of an ontology. As proposed in the Methonotology, by Fernández-López, the evaluation step was included as part of the stages to build ontologies [9]. Morán et al. and Danial-Saad et al. indicated that the evaluation is to be conducted with experts and potential users of the ontology, to give their perception of it, its program and documentation [7], [29]. Morán et al. evaluated their ontology-based design model with two groups, one consisting of six software developers and one with six specialists in rehabilitation. The purpose of the evaluation was to determine the ontology's usability and respectively the level of importance of the classes included [29]. Meanwhile, the Delphi method, as used by Danial-Saad et al., included two rounds of validation which were conducted with experts by rating the list of items, determining their relevance and ultimately reaching a consensus [7].

As can be distinguished, PSS ontologies are typically generated by involving key stakeholders, either for developing or evaluating the ontology, or for the development of the PSS it represents. No ontology was found that formally presents the development of SWEPH, as well as the participation of its key stakeholders and their requirements. Therefore, a preliminary literature search was conducted to identify the design requirements of (re)habilitation devices and other similar artefacts, together with their influence on UX. Botelho F. H. F. focused on the development of assistive technology for children, and emphasised on the importance of having the adequate size, type and quality when it comes to developing assistive technology for children [5]. This is necessary to avoid impairing the motion of the wearer, as indicated by Pacchierotti et al. [32], as well as ensure that the components are placed accurately on the body [31]. Rather than following a traditional design approach, practising a more empathetic approach helps to achieve supra-functional devices [34]. For instance, designing for wearability is important to be able to place the components conveniently, whilst making it easy for the caregiver to don and doff the device [22], [37].

Another fundamental design requirement is to keep the device simple, small and compact, whilst considering the shape and fit on the body, to make the design follow its smooth natural shape [17], [22], [32], [37]. The weight of such devices is recommended to be kept lightweight [2], [17], [37]. However, Pacchierotti et al. recommended comparing the weight of the device with the strength of the body part's musculoskeletal support where the device will be worn, as it would make a difference if the device will be worn on the lower or upper limb [32]. Comfort is another important aspect to consider [17] [22]. Rough surfaces, sharp edges and tight bands should be avoided to prevent discomfort to the wearer. Meanwhile, safety was accentuated in various studies to ensure the user and the surrounding personnel are not harmed, and avoid such devices from causing any rashes since they make direct contact on the skin [2], [10] [17], [26], [31], [35]. Since SWEPH fall under Class IIa of medical devices according to the Medical Device Regulation (2017/745/EU) [28], they must adhere to standards and regulations to make sure they meet the safety requirements and respective performance principles [10].

Focusing on UX, Bitkina et al. highlighted that a poor design other than possibly leading to the user feeling uncomfortable, it can impact the operation of the device [2]. A user-friendly design is recommended to help the users interact well with the device and use it properly to achieve their goals [2], [35]. If the users find it difficult to use the device, there will be a high probability of misuse which could influence the quality of therapy, possibly leading to harming themselves instead. Although usability is considered a major subset of UX in the context of medical devices, UX consists of two other elements: affect and user value [34]. Park et. al proposed definitions of UX and its three corresponding elements to help design either products or services. Usability focuses on the performance aspect of the product/service, meanwhile, affect encompasses the emotions generated based on the interaction of a user with a product or service. The sub-elements of affect consist of simplicity, delicacy, texture, colour, attractiveness and luxuriousness. On the other hand, user value is the subjective worth the user allocates to a product or service. Some of the sub-elements of user value include self-satisfaction, pleasure, attachment and customer need [34]. Usability, affect and user value provide a holistic understanding of UX, including both pragmatic and hedonic qualities.

In order to implement the aforementioned requirements appropriately, a co-designing approach should be adopted to ensure users' emotions and desires are taken into account, which leads to decreasing the rejection rate of such devices [4]. In the study conducted by Perara and Ranasinghe, various stakeholders were involved to develop habilitation products for children with hemiplegic cerebral palsy [35]. However, the prospect of fabricating these devices by AM to achieve more tailored devices was overlooked in their study.

The above extensive literature search indicates that there is a gap in devising an ontology which would guide design engineers to develop SWEPH fabricated by AM and which provides a high-quality UX, based on a holistic view of the requirements of multiple stakeholders. The aim of this ontology is to eventually facilitate the design process of SWEPH and increase the acceptance rate of these devices, whilst taking advantage of the benefits offered by AM.

3 METHOD

As depicted in Figure 1, the outcomes of two previous studies, conducted with the aim of identifying the requirements of SWEPH from the key stakeholders and design engineers, were used as foundations to develop the ontology presented in this study.

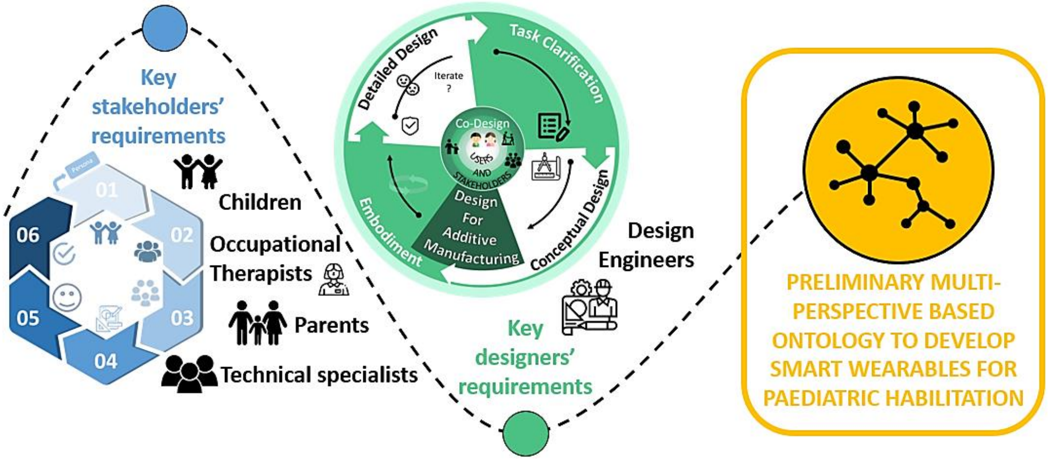

Figure 1: Representation of the studies leading to the preliminary multi-perspective-based ontology.

The first study takes a multi-stakeholder approach to generate key requirements to design SWEPH, emphasising on children with cerebral palsy as the primary users [4]. The stakeholders who participated in this study includes these children, their parents, occupational therapists and technical specialists. To have a concrete idea of the children's needs and desires, profiles including individualistic aspects were generated. The rest of the stakeholders were approached via focus groups, with three sessions in total, one for each stakeholder category [4]. Meanwhile, Bonello et al. [3] conducted semi-structured interviews with design engineers who had previous experience in designing medical devices and with supplementary experience in designing assistive technology, products for children and rehabilitation wearables, as well as UX design and AM.

Following both studies, thematic analyses were conducted to analyse the data collected, identify codes and construct themes respectively. These themes identified from the focus groups include the necessity to co-design alongside users and other key stakeholders, the importance to motivate the primary user to interact with SWEPH, user-centred approach to designing personalised and modular devices for individual children, the key characteristics to consider when designing the physical device and the serious games, utilising SWEPH at social environments and setting up factors to acknowledge, as well as motion capture and real-time data specifications. The main themes identified from the study conducted with the design engineers were the AM prospect to fabricate SWEPH, UX design to additive manufacture such devices and the participation of stakeholders.

Following the literature search of design requirements in Section 2, together with the outcomes of the aforementioned studies [3-4], a top-down approach was employed to determine the classes of the PSS. This approach initiated from the most general components of SWEPH and its respective service system, going into more specific characteristics such as the requirements, the respective users, AM opportunities and UX aspects. Protégé 2000 was used to create and manage the proposed ontology, as it is commonly used to populate and manipulate ontologies, being a free open-source platform {http://protege.stanford.edu/} [30].

4 PROPOSED ONTOLOGY MODEL

The proposed ontology represents the PSS of SWEPH, encompassing UX and AM elements and their relation with users and other stakeholders. Figure 2 illustrates the multi-perspective ontology characterised by five main classes and their respective sub-classes, depicting the relations created.

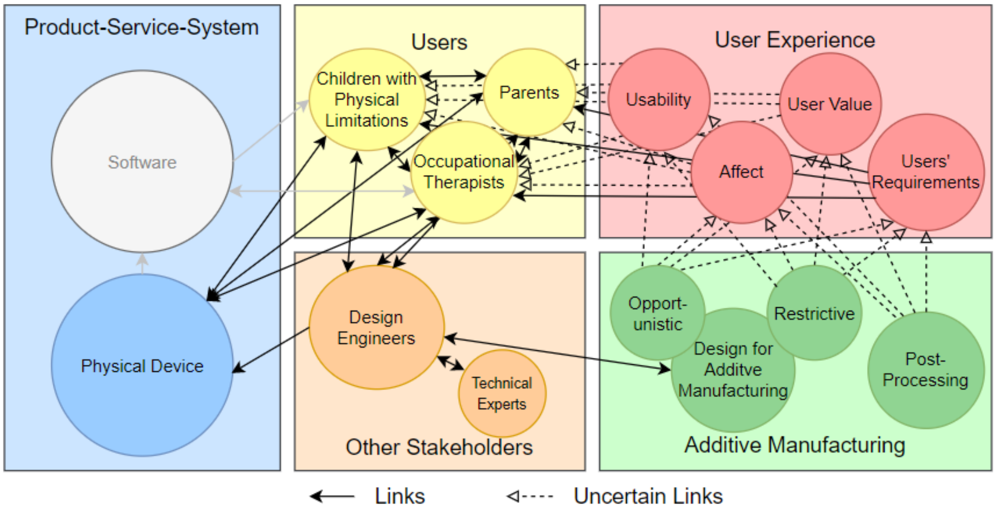

Figure 2: A multi-perspective-based ontology, representing its classes and respective links correlating the sub-classes.

The links representing these relations were formed according to the outcomes of the previous studies and literature search, representing the dynamics of the PSS and the users' as well as the intervention of the other stakeholders in the development of SWEPH [3-4]. Figure 2 highlights the links which are considered as uncertain, as the correlations between users, UX's sub-elements and AM were overlooked in previous studies. The means to confirm these uncertain links and evaluation approaches to verify and validate the overall ontology will be elaborated in the discussion section.

The PSS class consists of the physical SWEPH, which is worn by the children receiving therapy, on either one of their upper limbs. These bespoke SWEPHs will be additive manufactured and made to fit the primary users who will be interacting with them. Meanwhile, the software comprises the serious game that the user interacts with to carry out the therapy exercises, portrayed on a peripheral device. The peripheral device is also used as a mean to immerse the user in an extended reality environment, providing feedback on his/her performance. As indicated in Figure 2, in this paper we will be excluding the software sub-class from the ontology. Rather the efforts are made on how the rest of the classes are linked. The three user groups who will be interacting with such a system include the children with physical limitation, being the primary users who make direct use of the device, and the occupational therapists (secondary users) who do not interact with the device directly, but mostly indirectly to provide input or either receive an output. Meanwhile, the tertiary users in this case are the parents who are directly affected positively or negatively by the outcome of their child's interaction. As these three user groups interact differently with the system, they undergo different experiences. These experiences, as explained previously in Section 2, entail the three elements of usability, affect and user value. Additionally, user requirements, preventing rough surfaces and designing durable devices, among other, which resulted from the previous studies mentioned in Sections 2 and 3 were included as part of the key characteristics which eventually influence the users' experiences. The other stakeholders involved are the design engineers who design SWEPH to be fabricated by AM. In addition, technical specialists who help to shape the functionality and usability of the device and the respective serious game [3-4] are also incorporated.

Furthermore, the design engineers are responsible for the implementation of DfAM tool. In this study, 'DfAM in the strict sense' is considered, which targets the design process, and as portrayed by Kumke et al. consists of two elementary types; opportunistic and restrictive. The former refers to the guidelines which assist the designers take advantage of the design freedom attainable by AM, such as topological and parametric optimisation. On the contrary, the latter deals with design rules to guarantee manufacturability, for instance designing for a suitable clearance between two parts depending on whether the parts are meant to be moving or connecting [24-25]. In this ontology, such aspects are related to UX elements, as they can impact the usability, affect, user value or user requirements, influencing the overall UX the multiple users undergo when interacting with these devices. 'DfAM in the broad sense' will not be considered in this study as it goes beyond the design stage, including activities such as selecting the most suitable AM process [25]. In addition, post-processing is included under AM as it impacts the quality of the final product and enhances the features to meet the respective design specifications.

These above-mentioned sub-classes encompass the third and fourth classes. The characteristics and product specifications of the physical device were included in the ontology as the third class. With regard to the primary users, sub-classes were added regarding their individuality, such as functional goals, cognitive level and anthropometric data, as well as subjective attributes, for instance, their attention span, fatigue and motivation which eventually have an influence on the end result and overall experience. The UX sub-elements were categorised as listed by Park et al. into the third and fourth classes [34]. Figure 3 visualises the categorisation of the sub-elements of usability, to indicate the manner they were classified in this ontology. Meanwhile, opportunistic DfAM represents consolidation and generative design, whilst restrictive denotes the layer height, infill density and pattern, as well as wall thickness used to manufacture [24]. In the case of post-processing, support removal, surface finishing and painting, amongst other aspects were added [25].

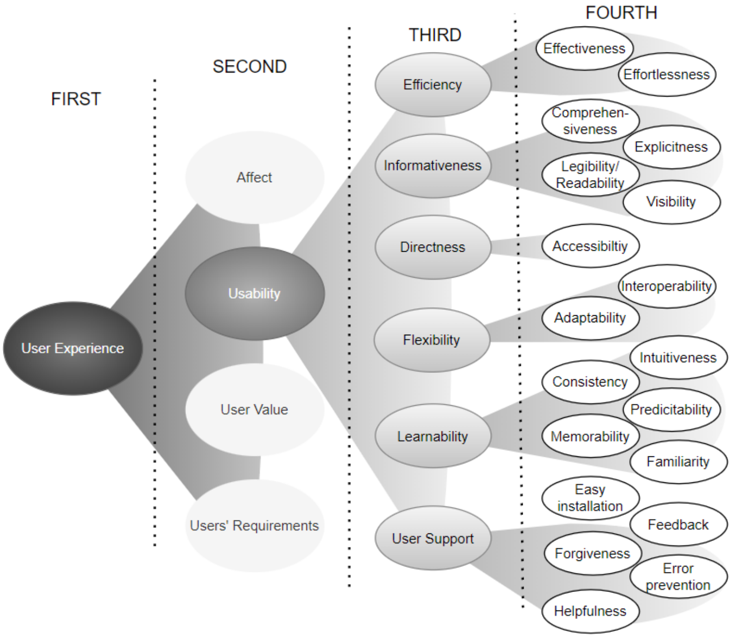

Figure 3: The stratification of the sub-elements of usability into sub-classes.

As a research boundary, since the emphasis was made on the physical device and how its design and manufacture influence its users, the impact of the software on the users' experience is not included in this ontology.

Figure 4 illustrates a sub-ontology modelled via Protégé. The engineering designers co-design the SWEPH with the key stakeholders: the child receiving therapy, his/her parents, the occupational therapists and other technical experts. Correspondingly, the children, the occupational therapists and the children's parents interact with the device, while the DfAM tool is used by the design engineers to optimally design and manufacture the device, taking advantage of the benefits offered by AM.

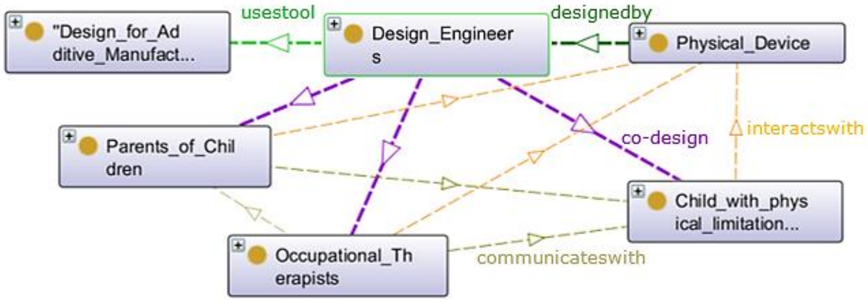

Figure 4: Sub-ontology of the multi-perspective-based ontology, depicting the correlation of design engineers sub-classes with other sub-classes in Protégé.

When interacting with such devices users undergo various experiences, which according to Park et al. are influenced by usability, affect and user value [34], as well as the users' requirements resulted from previous studies. Undoubtedly, a positive experience cannot be guaranteed just by taking into account the requirements and elements of UX. Experience is quite complex and rather subjective, which is influenced by the users' emotions [8]. However, presumed correlations between the user groups and the sub-elements of UX were created based on the users' type of interaction with the physical device, linking the user groups with the respective sub-elements of UX and user requirements.

The links created between the class of opportunistic DfAM and the fourth class of UX can be noted in the sub-ontology portrayed in Figure 5. Studies are still underway to confirm these links; hence they are considered as uncertain. These links were set up based on the potential impact the DfAM tool and post-processing have on the UX of the primary, secondary and tertiary users, as well as the requirements acknowledged in Sections 2 and 3. For instance, the proposed ontology establishes a potential correlation of opportunistic DfAM with attractiveness. This conveys that consolidation and/or generative design influence the users' perception of the device whether they perceive it as pleasing and attractive, amongst other aspects. Similarly, restrictive DfAM relates to the sub-elements of UX and user requirements. For instance, layer height effects the degree to which the texture of the product pleases the users. Furthermore, the post-processing applied impacts the aesthetics and surface characteristics of the final product, which might eventually influence the users' perception of the overall product.

5 DISCUSSION

The proposed ontology is a knowledge-sharing tool for design engineers to use during the design process, to develop computer-aided design (CAD) representations of SWEPH which can be fabricated by AM. Ontology Web Language (OWL) will be utilised to integrate the proposed ontology in CAD in order to assist design engineers in the development of these smart wearables. This ontology represents the relations between AM and UX, when either children with physical limitations, their parents or occupational therapists, interact with these devices. These unconfirmed relations create uncertainty for the engineers to design for high-quality UX. Thus, it is necessary to determine the degree of impact opportunistic and restrictive DfAM principles, rules and guidelines as well as AM post-processing have on the users. By settling these uncertainties, the proposed ontology can help alleviate the burden on design engineers to identify all the requirements of SWEPH and at the same time develop optimised CAD models purposely for AM, whilst also ensuring a positive UX for multiple users.

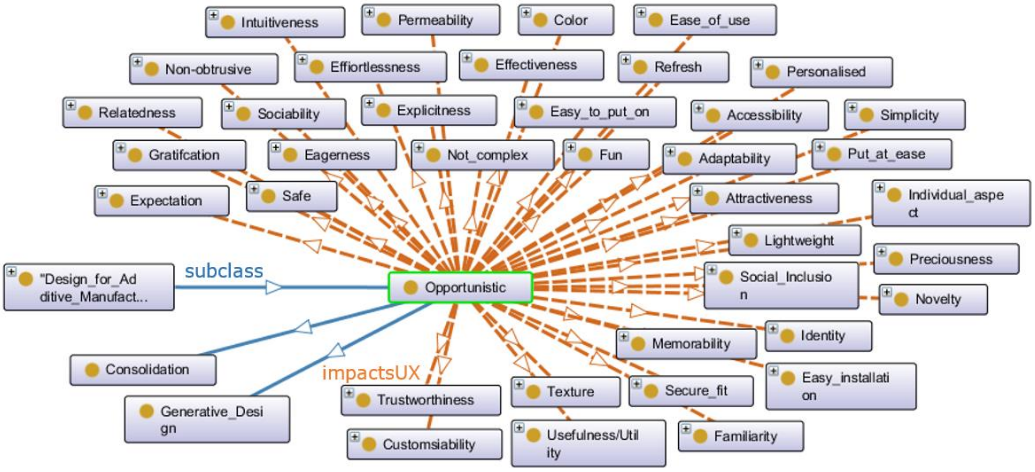

Figure 5: Sub-ontology of opportunistic DfAM and its relation with the classes of UX.

In the state-of-the-art, Gullà et al. conducted a learning procedure to confirm the relations of the uncertain links identified in the proposed user-product ontology, and eventually approve the a-priori presumptions. Hundred potential users of this ontology were approached to confirm the predicted relationships and assure a low degree of variance in the results [13]. As currently no studies have been disseminated on the relation of AM and UX elements in the field of SWEPH, further work needs to be conducted to confirm the uncertain links which were defined in the proposed ontology. This prospective study needs to encompass the three user groups in order to determine their interaction with additive manufactured SWEPH. The users should assess and give their insights on the design (opportunistic) and manufacture (restrictive) of the device and to what extent it impacts their experience in using it. Another recommendation is to rank the sub-elements of UX in order for the designer to be able to prioritise accordingly when designing such devices. Collecting these types of insights from the three user groups of SWEPH will help confirm or disprove the uncertain links identified in the multi-perspective-based ontology proposed.

To address these issues, a study is being conducted with children to start gaining insight into the impact of applying the DfAM tool on the subjects' interaction with a smart wearable device. From the preliminary analysis of the results, it emerged that children prioritise the functionality of the device with the serious game. Comfort and durability were ranked high, reflecting the importance for the children to wear the device without it causing any discomfort on their upper limb, and at the same time for designers to develop a robust device. These preliminary findings provide a degree of evidence that restrictive DfAM guidelines to obtain a comfortable and durable device are necessary to achieve a positive experience for the primary users. Moreover, by taking advantage of AM and consolidating SWEPH into one or a few parts can help make the device easier to wear. In addition to opportunistic DfAM, generative design allows for sizing the parts according to anthropometric data of the children's hands, whilst making it possible to achieve aesthetic designs which go beyond the designers' imagination.

Furthermore, the ontology can be made more exhaustive by encompassing the serious game and the respective extended reality features. These classes create new relations with the users and the sub-elements of UX. Additionally, since SWEPH and the serious game fall under the Class IIa classification of medical devices, according to the Medical Device Regulation (2017/745/EU) standards and regulations should be added to the ontology to ensure the design engineers develop devices which are safe for the users and can eventually make it on the market [10], [28]. Examples of these standards include; ISO 14971:2019 *Medical Device - Application of risk management to medical devices*, IEC 62366-1:2015 *Medical Device - Application of usability engineering to medical devices* and ISO 13485:2016 *Medical devices - Quality management systems - Requirements for regulatory purposes*, among many others [19-21].

Along with confirming the links which were deemed as uncertain in Figure 2, as underlined by Gómez-Pérez, evaluation is required to verify and validate the overall knowledge-sharing ontology, its documentation and software environment [12]. Verification needs to be conducted to make sure that the ontology is correct, whilst validation guarantees that it presents precisely the system it is meant to resemble. In this case, the evaluation is to be conducted by the design engineers, as they are the potential users of the proposed ontology. Insights from these subjects are essential in order to enhance its content and perceive its usefulness to aid engineers during the design process and additive manufacturing of SWEPH.

6 CONCLUSION

The main contribution of this paper is an ontology to develop smart wearables for paediatric habilitation. The proposed ontology is based on the information collected from multiple stakeholders to develop a multi-perspective knowledge-sharing tool. It revolves around the main three user groups, classified under primary, secondary and tertiary users, who are the children with physical limitations, the occupational therapists and the parents of the children, respectively. Noticeably, each user interacts differently with the wearable device and as indicated in the ontology proposed, 'DfAM in the strict sense' has an impact on their experience. Thus, this ontology provides a holistic view for the design engineers to comprehend the effect of implementing the DfAM tool on the UX of these three user groups. However, future work is required to confirm the uncertain links established, as well as to evaluate the complete ontology. Ultimately, this ontology shall help design engineers to develop SWEPH so as to decrease the users' rejection rate by ensuring a positive user experience.

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