Title:
Challenges of Integrating Industrial Product Design CAD packages in Commercial New Product Development in SME settings

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Keywords:
Human Centered Design, SME, Commercial CAD packages, Chemotherapy-Induced Peripheral Neuropathy, New Product Development, Wearable design

DOI: 10.14733/cadconfP.2023.184-188

Introduction:

This research focuses on one of the many challenges faced by industrial designers in SMEs with commercial CAD packages and offers solutions to overcome these limitations for new product development. Although CAD packages are crucial for design finalisation, CAD tools have limitations to assist the design conceptualization stage and designers struggle to transition between different stages of the design process. This gap in resources means it is necessary for designers to rely on traditional design tools such as sketching, as well as formulate creative solutions while using CAD tools for successful product development.

This commercially funded research in collaboration with Innovate UK and a medical SME in the UK is aimed at pioneering medical device innovations in the field of chemotherapy side effect management. The project is aimed at the design and development of a cryo-compression delivering system including a miniaturized device and wearable limb wraps to prevent the dose-limiting side effect of chemotherapy called Chemotherapy Induced Peripheral Neuropathy (CIPN). The case study investigates the challenges of using 3D CAD tools for the leg wearable design as part of the CIPN system.

Background, challenges using CAD for design and development in SME's:

Small and medium-sized enterprises (SMEs) are significantly important to the global economy as they lead economic growth and employment. Pursuing innovation enables SMEs to survive in tight competition, economic crises and compete against larger organizations [2]. Industrial or product designers are responsible for driving this innovation, by creating and developing concepts and specifications that enhance the function, value and appearance of products and systems for the mutual benefit of both user and manufacturer [5]. However, in an SME setting, knowledge, and capabilities to adopt technological innovation is limited [2]. Hence, it is crucial that the designers work within limited resources including minimal number of CAD packages to produce commercial products. In recent years, 3D CAD has become a vital tool in new product development, as it allows designers to create accurate design representations replacing manual design drafting, allowing design development, alteration, and optimization [1]. However, one drawback noticed in commercially used CAD packages is the lack of built-in support for conceptual design [8], which in an SME setting can potentially have negative impact. This paper analyses this gap in commercial product settings using a case study of the development of the medical cryocompression leg wrap in an SME environment, and discusses the challenges, and offers

solutions for designers to creatively use the commercially available CAD tools to deliver innovative commercially viable products.

During the ideation stage, designers aim to create the maximum number of evolving concepts possible. These are then modified or combined to form design solutions that are developed and finalised. During ideation, focusing on details is unnecessary, and more importantly keeping ideas vague and incomplete is important to prevent limiting the designers' creativity. However, currently available CAD packages require precise and quantitative design information to compute a 3D model, which is typically not available in the design ideation stage and evolving these designs can be time-consuming. Also using CAD packages in the ideation stage can lead to creativity-hindering effects like circumscribed thinking, premature fixation, and bounder ideation [8]. Due to this limitation in CAD systems, designers are still using traditional design tools like freehand and digital sketching, and model making for concept generation. The downside of using traditional design tools is that the conceptual outputs delivered through sketching and modelling need to be reproduced in CAD which can be a time-consuming and error-prone process, and the lack of 3D geometric information in sketches can cause difficulty in interpreting the designs algorithmically limiting the automated process [8]. Some argue that CAD offers sketching facilities, however, commercially available CAD tools with some "pseudo-sketching" capabilities are far from being a satisfactory alternative to sketching as they are oriented towards detailed instead of conceptual design [4]. There are some new developments in the field of computer-aided sketching (CAS) which provides a sketching environment for the designers that 'enhances their talents for conceptual design and innovation, and at the same time provide full integration with the subsequent phases of the product creation process' [4]. This development is promising; however, a usable product is not yet delivered.

Depending on the new product development setting, the design output expectations are different- for instance, in an academic environment, expected research outputs are often conceptual designs whilst in a commercial setting technically viable manufacturable products are also expected. Available human and financial capital and associated risks are also considerations for new product development. In the case of an SME, with limited financial and human resources, investing in multiple CAD packages for new product development is not feasible [9]. Most commercially available software also has steep learning curves with some software knowledge being less intuitive and not necessarily being closely linked to the design process [8]. Hence, often the smaller design teams in SMEs will not have the time or expertise to learn and use these systems, forcing the designers to find alternative and mostly not conventional solutions to transfer design solutions into CAD to then push to manufacture. Whilst developing the cryocompression leg wearable in the medical SME, the authors have experienced the challenges explained above during the design process. This is explained in the case study below, along with the employed design team's solutions to overcome these challenges.

Case Study: Development of cryocompression leg wearable for (CIPN) management:

CIPN is a common dose-limiting side-effect of taxane-based chemotherapy, causing progressive and often irreversible pain/sensitivity in the hands and feet, hampering the quality of life of cancer patients. Prevention/treatments for CIPN are not well-developed and are urgently needed. Limb cryocompression during chemotherapy has demonstrated promising early data for preventing/reducing CIPN severity. Currently there are no medical devices available that are dedicated to the specific requirements of CIPN prevention affecting 1.4 million patients worldwide and over 30,000 in the UK annually [7]. A collaborative and multidisciplinary approach is adopted by the medical SME to develop this dedicated CIPN treating system. This study only focuses on one aspect of the system – the design and development of the cryocompression treatment delivering medical grade leg wearable/ wrap. The aim was to design a one size fits all leg wrap design that covers and has close skin contact with the patient's leg up until the knee providing optimum cooling and cyclic compression, while also ensuring safety and comfort for the user.

Methodology:

This project utilizes a human-centered design thinking approach to assist with the development of wearable medical devices. This includes focus on human factors such as usability, safety, ergonomic

and anthropometric research collected through primarily stakeholder activities and combined with secondary data available. This collated data is used to inform the design process.

Considering the limitations of a medical SME for new product development, a collaborative approach using the UK government's Knowledge Transfer Partnership (KTP) is employed for gaining access to resources such as funding, knowledge, and support for feasibility studies.

Computer-Aided Design:

Designing wearables poses challenges of its own as designing for a complex organic shape such as the human body is not generally well supported in heavily engineering-based NURBS packages like Solidworks. Hence for this project, a plethora of CAD packages was considered.

Textile design and pattern-cutting oriented CAD packages like Optitex (as seen in Fig 1) [6], and Clo 3D were analyzed. However, they were not found suitable for data mapping of polygon-based data to NURBS software for taking to manufacture. Also, the cost and learning curves for these textile packages for industrial designers are significant, therefore require further time and resource.

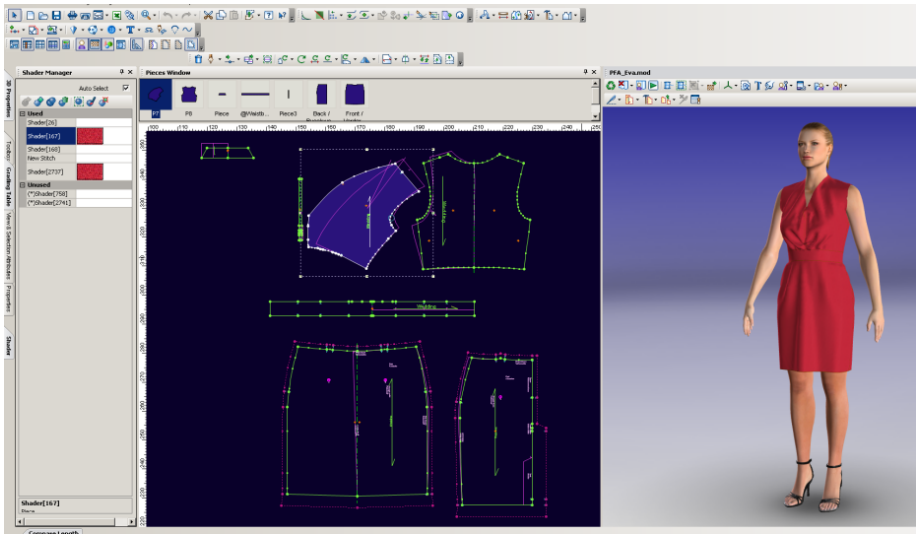

Fig 1: Evaluated textile software Optitex [6].

Other software like Alias from Autodesk and Rhino were also considered, however, this being a commercial project in an SME setting, the cost that is associated with such software packages for use in a single project was not supported by the commercial partner.

As a suitable CAD system could not be identified for the design conceptualization, traditional design tools like freehand and digital sketching, and model making were employed for concept generation, and in the design testing and finalization stages 3d engineering tool Solidworks was used to create 2D patterns for prototyping and tool making.

Design and Development:

The design process of the leg wrap went through multiple design iterations before reaching the final design (as seen in Fig.2). Being designed in accordance with a Human Centered Design approach, user's feedback is integrated in the entire product development process. Each iteration of the design involved several techniques such as design workshops, focus groups and interviews to gain usability feedback.

Fig 2: Iterative design process for the leg wrap.

As a 3d CAD package that supports all stages of the design process is not available, the design team used a wide taxonomy of design representation like sketches, diagrams, in-house and professionally made prototypes to test and evaluate the design concepts. Evaluation of each iterative product prototype was done with multiple stakeholders including patients, nurses, GP, technicians etc. to redefine the design requirements before the next design iteration, to continually improve the medical device. During this phase it was recognized that the process of physical evaluation would have been more efficient if 3D tools would be capable of initial evaluation of the design concepts.

A multidisciplinary team approach was also highly beneficial, promoted by the KTP partnership with the university. Drawing from the knowledge of different department like Arts, Humanities, Medical and Engineering including international partners enabled early investigation for the design team at the SME to enable safe analysis and accurate adoption of commercial software for developing leg wearable.

Industrial design process has many phases including research, ideation, concept evaluation, development and finalisation, and at each of these stages of this project, designers had to find creative techniques to use engineering-based CAD packages to asses concepts, make prototypes, test and deliver final design. In this wearable design there are two parts – a soft plastic RF welded heat exchanger and a fabric outer cover. The sizing of the wearable was informed by thorough anthropometric research conducted in house. The ideal option for the designer during the ideation and concept evaluation phases was to be able to model both the plastic heat exchanger and fabric outer cover concepts in a solid modelling package and simulate it by wrapping around a leg to check for fit and sizing. Considering this fabric like design is difficult to model in Solidworks, flat 2d patterns were modelled instead, which was then laser cut and sewn together to test the concept. This method proved helpful, as multiple iterations were created easily based on the anthropometric data, by just modifying the data input into Solidworks. A flat pattern of the wrap created in Solidworks was also provided to manufacturers for both professional prototypes and final close to commercial product. Although these 2D patterns can be generated in textile packages like Clo 3D as well, besides the reasons mentioned above, industrial manufacturers preferred engineering 3D CAD files for ease of translation.

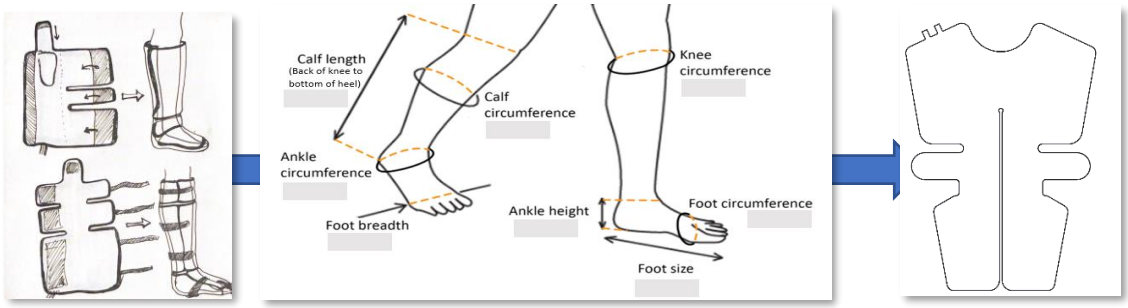

Fig3: Concepts and anthropometric research used to create 2D patterns in Solidworks.

Conclusion.

Although there are many advanced CAD tools developed and packages available for research and academia, implementing these packages into a commercial environment like an SME is still difficult. Hence, there is an opportunity here for CAD developers and relevant industrial design stakeholders to collaborate for creating a new SME or commercial environment focused CAD package that is suitable to cater for all stages of the design process while also having the benefits of advance tools like CAM, AI, VR and tools for testing, production, and simulation. This would enable design teams in SMEs to speed up the design process whilst still delivering creative and technically viable end products.

Up until then, as evidenced in the case study of the commercial leg wearable design, designers should employ creative methods to use currently available CAD packages to aid the design process. Where the product form is complex and organic, as evidenced in the case study, making 2d flat patterns, and using techniques like laser cutting and sewing can fasten the design process phases such as ideation and concept evaluation. Also, to reduce the risk element in research and development, SMEs can consider collaborating with international teams and academic institutions to draw from their knowledge on CAD packages before investing in one.

Acknowledgements

The authors would like to thank Innovate UK Knowledge Transfer Partnership and Paxman Coolers Ltd for their continued support and funding of our research. Special thanks also to the National University of Singapore including The N.1 Institute of Health for their collaboration, funding, and support of this project.

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