APPLICATION OF SCENARIO PLANNING IN ANALYZING THE POINTS OF CUSTOMIZATION FOR RAPID MANUFACTURING

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ABSTRACT

Rapid Manufacturing (RM) is envisaged to be the enabler for customization. In RM, the components are fabricated by adding successive layers of material together, based on three dimensional computer aided design (3D CAD) data. The CAD data can be either developed from scratch or from scanning existing objects. The development of tool-less production in RM makes it economically viable for small volume production. RM would be suited to cater for niche markets requiring unique end products, making it more affordable. This fits in well with the requirements of customization, which manufactures a product or delivers a service in response to a particular customer's needs. For the customization of consumer or medical products to fit an individual's body geometry, it will be necessary to scan the body in order to get the exact measurements. This paper looks into the different possible points of customization for consumer and medical products based on RM. Scenario planning has been used to explore the different set-ups for both groups of products and to analyze the challenges faced within each set-up. The research found that many products have similar situations while some require more specialised set-ups than others, especially the medical products and those used for the disabled. The medical products are restricted to a few scenarios while the consumer products will be able to have variations, depending on the nature of the product and the level of customization service available.

KEYWORDS

Rapid Manufacturing, Customization, Mass Customization, Scenarios, Points of Customization

1 INTRODUCTION

Rapid manufacturing (RM) has already been adopted in several industries. The hearing aid, automotive and aeronautical industries have started using RM techniques for the production of some parts. In the aeronautical industry for example, environmental systems inside fighter jets are printed out by rapid prototyping machines and have led to savings and reductions in cost and production schedules by about 50% [1]. Major hearing aids companies have adopted RM as their mainstream production technique [2]. Siemens Hearing Instruments has been producing customized hearing aids using RM techniques at a production rate of 2000 pieces per week [3]. In the automotive industry, RM has been adopted in the development of Formula 1 (F1) racing cars. The Renault F1 team has been using RM techniques for the production of certain parts that are fitted directly to the car [4], and has been able to produce parts with multiple component assemblies as a single part [5]. In other industries, the US military has set up a Mobile Parts Hospital at sites in Kuwait and Iraq, printing parts for their equipment. The army is able to replace broken parts within hours instead of waiting days or weeks for the new replacement [6]. Besides

industrial usage, RM has also been adopted in consumer products. MGX, a division of Materialise of Belgium [7], has been using the same technology for the fabrication of customized and limited edition lamps with complex designs.

The potential of RM is immense. An industrial led project has been funded by the European Commission to investigate the possibilities of adopting RM technique for the customization of more consumer and medical products. The project, known as Custom-Fit[1] under the Sixth Framework Program, involves 33 partners from around Europe. The partners include small-medium enterprises, research institutes, consultancy organizations and universities. The aim of the project is to create a fully integrated system for the design, production and supply of individualized products. These products are customized to fit the requirements of the consumers' both geometrically and functionally. The parts or components will be produced directly using computer-aided design (CAD) data, i.e. RM. The project focuses on a number of products which can be broadly classified as medical and consumer products. These include, for medical products, prostheses and implants; for consumer products, helmets, tennis grips and seats.

The project also looks into the socio-economical implications of RM and customization, such as market opportunities and issues related to management, safety, health and environmental etc. One of the issues which the project analyses is the interaction interface between consumers and manufacturers. Since the product will be customized to suit the consumers' body geometry, it is then necessary to obtain their body measurements. This will be done by means of scanning and the data can be used for the design of the product and later for fabrication on the machines.

This paper aims to explore where the "point of customization" can be set up within the supply chain. Through the use of the scenarios planning technique, the different possible options for setting the point of customization will be assessed. Following this introduction, a literature review of RM, customization and scenario planning will be presented. The different scenarios for the point of customization will be discussed and an outline of how these points of customization are applicable to different types of products will be described. The paper will conclude with discussion and conclusion.

2 LITERATURE REVIEW

To understand the advantage of using RM for customization, it is necessary to understand the characteristics of RM and mass customization which will enable a better understanding of why RM is suitable for mass customization. This section will also explain what is scenario planning and thus why it is suitable for this research.

2.1 Rapid Manufacturing (RM)

RM is a new production method which has evolved from the existing rapid prototyping technologies based on additive manufacturing techniques. It is the direct production of the parts or even the final products directly from digital data, eliminating all tools [8, 9]. The components are fabricated by adding successive layers of material together, based on CAD data. From the manufacturing perspective, there are several advantages in adopting such a method. Firstly, designers are able to have design freedom [10]; they are free to design complex geometries the RM machines will be able to fabricate. The direct fabrication of these parts using CAD data also means that tooling is eliminated. Designers do not have to worry about whether a mould can be made for a particular design or the number of parts that are required to make a component which lead to increased cost of tooling. Any changes to the design can be made quickly without much effect on the cost. At the same time, the long lead time for delivery of the tooling can be avoided, shortening the time-to-market of a product [11]. Without tooling, it is possible to fabricate parts and products in small quantities which would not otherwise be economically viable. RM enables low volume production at a more economical cost and as shown by Ruffo et.al. [12], without the

[1] Custom-Fit is the project acronym, the full project title is: A knowledge-based manufacturing system, established by integrating Rapid Manufacturing, IST and Material Science to improve the Quality of Life of European Citizens through Custom-Fit Products.

cost of tooling, cost of low volume production using RM decreases much more significantly than injection molding.

2.2 Customization

As society becomes wealthier, consumers become increasingly refined in their desire and they know exactly what they want. Consumers want choices, individuality and customization but only if the product or service fits exactly their needs and desires [13].

It used to be the privilege of the rich to enjoy customized products but mass customization has enabled the provision of customized services for the majority. The concept of mass customization is to have high volume production of individually defined goods in a cost effective way [14-16]. Goods and services are individualized to satisfy a very specific customer need, at an affordable price [14]. There are different levels of customization and it is necessary to define the levels a product can be customized. Piller [17] has highlighted three distinct levels that can be applied to personal use products:

1. Style: deals with the aesthetics of a product, allowing the customer to choose colors, fabrics and logo. It is common for these products to work around a standard model with a series of options for each change for example the customized boots offered by fashion company Timberland® [14].
2. Fit and Comfort: customization around personal body geometry to create a well fitting garment, this is especially appropriate for clothing such as the jeans made by fashion company Bodymetrics [18] and other products that fit close to the body.
3. Functionality: when a product performs a specific task its functionality may be optimized by customization, adaptations may include level of support, cushioning or body alignment. Some footwear manufacturers, like Adidas in their mi-Adidas product [19] have integrated functionality into their customization process to offer a product not supplied by others.

Although discussion of customization is usually associated with general consumer goods (such as clothing, shoes, bicycles, computers etc), medical products in fact require a greater degree of customization. For example, a mandiblular implant. As each individual's skull is different in structure and shape, it is difficult to find an implant replacement off-the-shelf. Each piece of an implant has to be custom-made and the lead time is about one month or even as long as three months. Very often, a surgeon will still have to make minor adjustments to the implant during surgery so that it fits the patient's anatomy. Unlike the consumer product, the production of customized medical products for the patient is often necessary. A correctly customized implant would help to reduce the complexity of surgical reconstruction techniques and surgical time [20].

2.3 Rapid Manufacturing and Customization

RM is envisaged to be the enabler for customization [2, 9]. As discussed earlier, the development of tool-less production in RM make it economically viable for small volume production. RM would be suited to cater for niche markets requiring unique end products. This fits well with the requirements of customization, which manufactures a product or delivers a service in response to a particular customer's needs [16]. This in turn means producing a one-off item. With greater degree of design freedom, RM potentially, will be able to cater to any geometric requirements. A good example of adopting RM for customization is shown in the case of hearing aids production [2]. A hearing instrument has to fit the user's ear tightly and comfortably to ensure good acoustic seal [21]. Phonak Hearing Systems and Siemens Hearing Instruments have worked together to develop the additive manufacturing technique for producing customized hearing aid shells. The new production process has improved the geometrical accuracy of the product and eliminated human error [1]. RM has also been targeted for medical applications, such as scaffold fabrication in tissue engineering [22-25]. The main advantages of RM for scaffold fabrication includes customized design to match the complex anatomical geometry of human body, direct fabrication using CAD data and most importantly, shortening fabrication time.

2.4 Scenario Planning

Scenarios are stories about people and their activities [26] that are specifically created [27-29]. This technique has been used as an informal method by systems developers in designing new systems [26]. They have also been used in organization planning [28-30]. Scenario planning is one of the "foresighting techniques" [31] organizations have used for strategic planning. The history of scenario planning lies in military strategy [32], having been used throughout the ages to plan battles in a kind of war game simulation. More modern use of the term and process began at the Rand Corporation [32, 33] with Herman Khan, on projects for Air Defense in the 1950's. During the 1960's a rival school emerged in the field, based in France at the Center d'Etudes Prospectives under the heading of Gaston Berger [32, 33]. Most well known is the work done at Royal Dutch Shell in the 1970's and 80's [29, 32, 33] in a time of great uncertainty for the oil industry. There is a general consensus between authors on the reason for applying scenario planning - dealing with uncertainty and an unpredictable future [28, 29, 34, 35]. Scenarios form a risk-free environment to explore possibilities, like a windtunnel [32], that allows ideas to be explored in a variety of realistic situations. By their nature as collaborative stories, they encourage social interaction [29] between their writers and develop creativity [36]. Usually linked to strategy they can be used to show the end goal, assess what is missing and help create the path to get there [36].

The scenarios themselves can vary in detail [27], some create elaborate dialogue [37] moving outside of the specific content but they generally focus on the functions of new technology and their interaction with the environment [27] without going into detail on the characters involved. The assessment of scenarios is more difficult, as they are predicted future events there are no statistics or evidence to use and it usually comes down to personal judgment [30].

3 SCENARIOS FOR POINT OF RM CUSTOMIZATION

For this research, the scenarios created are based on what the customer will experience when choosing to customize their products. They are not elaborate, do not contain specific characters to cloud the situation, and are written from a perspective that is neither positive nor negative; just what is perceived from what is known. Several scenarios have been identified as the possible point of customization.

3.1 Home Visits Service

Home visits are made by a specialized team to an individual customer who has placed an order for a customized item. The team will consist of a group of well trained personnel, equipped with a set of portable scanners and equipment required for acquiring body measurements. The scanning service provided will be mainly external such as scanning the shape and size of the head, foot or hand.

This team could be set up by a retailer to cater to its own customization service. It can also be set up as an organization (i.e. a scanning agent) to offer such service to the retailers through sub-contracting. It is foreseen that the cost of running such a team will be high and therefore it is very possible that such home visits will be offered for high end consumer products, especially in cases where the retailers would like to distinguish themselves by offering premium services.

In the medical field, the home visit services could be provided at different levels. For example in the United Kingdom where National Health Service (NHS) is provided, the "home visit team" can be run by the local trust that is responsible for a particular region or a group of hospitals. The team could belong to the region where it will be deployed to serve patients. The team might be run by a specialized health centre, to provide consultation in a particular area, such as in cardiology. It might also be possible that suppliers of medical equipment or products will work with the trusts or the hospitals to provide the home visit service.

3.2 Mobile Service

Mobile service has certain similarities to the home visit service, but the equipment used in this case need not be portable. This will typically be a vehicle which will consist of a scanning booth, a changing room and a consultation area. The staff working in the mobile unit have to be well trained in handling the equipment and, in the medical case, will need to be qualified medical personnel.

An example of mobile medical screening service is a mobile mammography van owned by Boca Raton Community Hospital in Florida, United States of America (USA) [38]. The van is equipped with equipment for mammography and has a team of certified mammography technologists to guide the women through the screening and two certified radiologists to interpret the films. The van could be booked by community organizations, associations or employers to provide screening for their female members.

Mobile scanning units can also be set up by retailers and serve a particular region or the whole country depending on the demand. For example, the mobile unit can be scheduled to visit a specific branch to serve the customers by appointments. Such service is already available in the clothing industry in the Netherlands. A fashion company Possen, has retail shops with a three dimensional (3D) body scanner and also trucks installed with a scanner to travel around the country to places where they have no retail shops [39]. For the mobile service, potential customers can book an appointment through the Internet and the truck will visit them to get their body measurements using the scanner.

3.3 Scanning Centers

Scanning centers are purpose made facilities to provide scanning services. They will be able to carry out different types of scanning, from scanning of body dimensions to Computer Tomography (CT) and Magnetic Resonance Imaging (MRI). The staff will be highly skilled and trained to perform all types of scanning.

A scanning center can be regional or there may be several centers within an area depending on both the demand and the population in the region. It may be the case that the scanning center is actually a hospital or a specialized center that provides consultation in a particular area. Any retailer, private practitioner, private or public hospital can buy time slots with the scanning center to make use of the facilities provided allowing them to use the technology with no capital investment. Such scanning centers are rather common in the United States of America (USA) [7, 40-43]. These centers, known as imaging centers, provide various different imaging services, from MRI, CT, ultrasound to mammography and bone densitometry. The patients can either be referred by their doctors or self-referred to screen for early disease detection [7].

It is not recommended that scanning centers provide services for both medical and commercial purposes simultaneously. It should be designed either solely for medical or commercial purpose. This is mainly because there are people who dislike the idea of visiting a hospital, such as the recognized Nosocomephobia i.e. fear of hospitals [44] syndrome, and they will definitely not go to a medical center to be scanned for personalizing a product. Secondly, consumers' experience issues associated with consumer products has to be taken into consideration when setting up such scanning centers.

3.4 In-Store

Scanning services provided by retailers will be located in the retail stores as in the example of Bodymetrics customized jeans on sale at retail store Selfridges in London [18]. There will be a dedicated site for carrying out the customization procedures. The customization facilities will include a scanning booth, a changing room if necessary and an area for consultation and facilities for reviewing the customized product. The consumers will be served by trained staff who are proficient in handling the scanning equipment and have good knowledge of the product.

Depending on the type of product and the level of customization, the scanning facility can be a "do-it-yourself" (DIY) system. In such cases, the facility will have to be "fool-proof", i.e. it has to be easy to

operate, with specific instructions and a friendly user-interface. An example of such a system would be the photo-taking booths which are available in most public places. These photo-taking booths provide clear instructions and the camera is initiated with the press of a button. Products such as helmets which require the scanning of the head are not likely to be the ideal target for a DIY scanner.

The customization options such as aesthetic design or styles (i.e. colors, design), comfort and fit can be provided using a DIY system. However, if customization in terms of functionality or performance is involved, this will require advice from trained staff. For example, in the case of mi-Adidas [19], consumers have the options for color, fit and performance. They are able to have different shoe sizes for left and right foot and select different cushioning in the shoes according to the anatomy of one's foot. This service is only available in stores with well trained staff offering advice for the cushioning after analyzing the weight distribution of the feet. It should be noted that providing customization is not only about providing an item which meets the specific requirements of the customers, it is also about providing a shopping experience to the customer [45].

3.5 Postal

The postal service scenario would involve the sending of a kit to the customer to obtain an imprint. This is only suitable for certain products in which the dimension of the body parts can be easily obtained and where indirect scanning is required, i.e. scanning of an imprint medium and no existing example of this system has been found. In such cases, clear and explicit instructions have to be provided for using the kit. It is important that once an imprint has been obtained and the molding has been set, it does not alter easily when subjected to changes in temperature, pressure or vibration. To ensure that the kit and the imprint arrive safely to the customer and retailer respectively, it is crucial to have a good logistical arrangement.

3.6 Internet

The Internet is another option as a point of customization since it is used widely and available at any time. However, the use of the Internet as the point of customization also limits the options for customization. It can be used only if simple measurement of the body is required (such as length of feet, diameter of head etc.) and when customization involves only aesthetic aspects such as design and color. An example is the customization of running shoes by Nike [46]. Consumers buying the "personalized" shoes from Nike's website have a limited range of customization options. They choose the size of shoes from a standard range and they have the choices for different colors to different aspects of the shoes and whether to have an identity on the shoe. A contrast to what is offered by Nike [46] is the customization of shoes offered by mi-Adidas [19] as mentioned in section 3.4.

Another example is from the fashion industry. As mentioned in section 3.2, Possen the fashion company provides both retail store and mobile scanning services. In this case, the customers have to go to a store or make an appointment for the mobile scanning service to have their body measured using the body scanner. The appointment can be booked through the company's website. Once the customers have their body scanned and their body measurement data are stored in the database, they could go on the company's website to select made-to-fit suit or shirt and are able to select different fabrics. It can be seen in this case that the Internet is still limited to the aesthetic aspect, the actual body scan still has to be carried out in a store or using mobile scanning service.

4 SCENARIOS FOR INDIVIDUAL PRODUCTS

For the products studied in the Custom-Fit project, i.e. helmets, grips, seats implants and prosthesis, each has its unique requirements and thus a different point of customization. Currently, with the exception of the medical product, the consumer products do not have any customization services. The following sections will attempt to describe "visions" of where and how the customization service can be offered to the consumers for the above mentioned products.

4.1 Helmets

The project looks into the customization of liners for motorcycle helmets. As shown in Figure 1, a motorcycle helmet consists of an outer shell which is manufactured from either thermoplastic or fibre reinforced plastic composite, an inner liner formed from expanded polystyrene and a comfort foam liner which is also expanded polystyrene but of a different density [47].

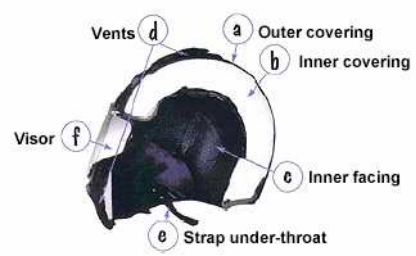

Figure 1 Cross section of a motorcycle helmet

Customization of helmet liners is more of a functional process than aesthetic. Colors and finish are not important as the liner itself will not be visible as it has a cloth inner layer. However, as part of the whole process customers will need to choose the shell color and pattern which must be considered as part of the process although it is not directly part of the research. These factors dictate the possible scenarios for point of customization.

4.1.1 Scenario 1 – The In-Store Experience "Vision"

The first and most obvious scenario is based around the in-store experience. Customers enter the store as for any helmet purchase; the full range of styles and colors are available for viewing and selection. Once this part is complete, the scanning process begins.

The customer is briefed about the scanning process by a trained member of staff who will also take note of personal details. As a head scan is required, a specialist area has been set out away from the general shop floor to allow for the fitting of a scanning cap, to hold down the customer's hair. When ready, the customer enters the scanning booth where instructions are fed over a loud speaker. The scan itself takes only a few seconds, but is reviewed on the computerized display before the scanning cap is removed. At this point the order is placed and the customer informed of the approximate time for delivery, at which time they will be required to come back to the store for fitting and collection.

Once in store, a check is made to ensure the product is as ordered and then the customer is notified that they can come to the store for fitting. For privacy purposes the fitting will take place in the off-shop floor area. The helmet must now be worn by the customer and the standard questionnaire followed and tests conducted to ensure the fit is correct and it is easy to put on and remove. If the customer and assistant are both satisfied that the product is correct the full transaction is completed.

4.1.2 Scenario 2 – The Mobile Scanner "Vision"

As the scanning technology is new and may require considerable investment, some retail chains or brands may decide to have a mobile unit that can travel around their sites and have higher machine utilization. Firstly though, the decision to buy has to be made and an outer shell chosen. This can be done either in store or over the Internet as it is purely an aesthetic part of customization, which may save the store money as no trained staff are required for this process.

After the choice of aesthetic features, an appointment would be made by staff at the store or by directly viewing the schedule on the Internet. The mobile unit would visit specific branches of the store on planned days allowing branches to book slots for their customer not necessarily at their own branch but more at the convenience of the customer. Data from the scan would be checked and then sent to the

manufacturing facility direct using a customer number obtained during the initial in-store or on-line phase.

Fitting would depend on the initial method chosen. If bought in-store, the finished product would be sent to the store for fitting, but if purchased over the Internet the product would be sent directly to the customer together with instructions for testing fit and the questionnaire to ensure all aspects have been checked. If the product is considered incorrect, the documentation should be completed in full and the product returned. Any further action would be dependant on the reason for return.

4.1.3 Scenario 3 – The Scanning Center "Vision"

As with the mobile scanner, the scanning center would require previous purchase of the helmet with all aesthetic choices made. Scanning itself would take place as with previous scenarios and fitting would be as in section 4.1.2.

4.2 Tennis Grips

Grips vary from helmets in the way the scan is performed. As it is a functional product that is based on the specific hold of the customer, a scan of the hand would not be sufficient to obtain the correct data to manufacture the product. Therefore an indirect scan of the hand imprint on a grip blank is used to provide the 3D model from which the product is made.

4.2.1 Scenario 1 – The In-Store Experience "Vision"

As the product only requires the hand to be used, no changing facilities will be needed so in a retail store the function could be performed on the shop floor.

It is first necessary for the customer to choose the tennis racquet they require or bring their existing racquet to the store. This can then be examined and sized to establish the internal dimensions of the grip to be manufactured. From there the customer will be asked to hold the existing racquet with their natural hold until they are happy with the feel. At this point the grip blank will be substituted for the racquet and the customer asked to recreate the hold positioning firmly to deform the medium. This form will harden to hold the shape before scanning, so as long as the customer is satisfied with the shape they will not be required further in the processing.

When the shape is set, it can be scanned in an appropriate space in the store either on the shop floor or in the staff only areas, whichever is most convenient. Alternatively the deformed medium can be sent to the manufacturer for scanning.

It will be necessary for the grip to be fitted by trained staff, so once delivered to the store the customer must come in and bring the racquet for fitting. If the grip feels correct to the customer it is attached to the racquet while they wait, and the finished product can be taken away.

4.2.2 Scenario 2 – Postal Service "Vision"

As grips have no aesthetic needs, except perhaps color which is a simple choice, the process could be completed by post. As with the store experience, a blank is used to store the hand imprint and it therefore may be completed by the customer at home.

Either by telephone to a store or using the Internet, an order is placed for a customised grip. A kit is dispatched to the customer for a specific fee to be paid upfront to cover materials with further payment for the complete service when the deformed medium is returned. The kit would contain a re-formable blank grip, in order that the customer can make several attempts at creating the perfect hold, a questionnaire to complete on the type of racquet it is to be fitted to and any color preferences, instructions on how to perform the imprinting process and the appropriate packaging material for return.

The forming process is as in-store, with the shaped medium being allowed to set before posting it back to the manufacturer. On completion of the product it is possible for the customer to visit a store for expert fitting or send it direct to the customer with fitting instructions. Where there is no interaction with trained personnel, a returns service is available.

4.2.3 Scenario 3 – Internet Limited Ergonomic Customization "Vision"

Some players are skilled in the game and happy with their grip and technique, but for those who require a little help with the correct finger alignment and would like a grip that is the correct size, a service without scanning would be possible.

In order to create the correct grip, the customer should not have their own hand impression scanned as that would serve only to reinforce the incorrect positioning. Rather the traditional method of measurement should be adopted, i.e. measuring from the tip of the third finger on the playing hand to the lower of the two creases [48]. Thus allowing for a customized sizing with a correct grip position.

The customer would access the system via the Internet and input the measurement required along with choice of colour and surface texture, along with information on which racquet it will be fitted to. This is all that needs to be done at this stage until the final product arrives with instruction on fitting.

4.3 Seats – Motorcycle

The process for motorcycle seats is very similar to the helmet. As both of these products are used for the same activity it would be prudent for retailers to combine the service wherever possible. A difference that occurs is that the seat is an indirect scan i.e. the scan of a deformed medium as opposed to the direct head scan, meaning different scanning equipment may be needed.

Scenarios for motorcycle seats would follow similar patterns of events to the helmets taking place in-store, using mobile facilities and at scanning centers, as in section 4.1.1 to section 4.1.3. The deformable medium used to create the scan would be fully re-formable to allow for repeated use. Mobile facilities that are used for helmet scans can be utilized without adding extra scanning equipment as the deformed medium can be stored for scanning at a later time back at its headquarters.

4.4 Seats – Disabled Children's Ride-on Toys

The other product considered under the seats category is seats for disabled children's ride-on toys (see Figure 2).

Figure 2 Children's ride-on toy

Although the end product is consumer based, it falls on the borderline between consumer and medical. Disabled individuals have different needs from able bodied customers and therefore would require more specialised facilities.

4.4.1 Scenario 1 – In-Store and Medical Scanning Center “Vision”

It is essential that specially trained staff are available not only to lift and hold the person correctly but also to position them in a suitable way to ensure they would be well supported in the final product.

The customer should initially visit a store holding examples of vehicles suitable for customization. Staff should be sufficiently trained to know how easily and how much the vehicle can be modified. At this time, the model and color scheme should be chosen. An appointment would be made to go to the local/regional medical scanning center to ensure the correct dimensions can be obtained.

As the customer arrives at the scanning center knowledgeable staff should be on hand to greet them and their parent/carer. A detailed explanation of the procedure should be given, involving the child as much as possible. All equipment should be in place to make the process as quick and smooth as possible. The child should be asked to sit onto the deformable material or be lifted and placed in position by the trained staff or parent/carer as is deemed best by those present. Where necessary the child should be supported in place until the seat imprint is completed to obtain the best possible result. As soon as the process is complete the child should be removed from the apparatus and made comfortable while the imprint is inspected for suitability. The customer may leave as soon as the imprint is correct to be recalled later for fitting.

It is considered that the fitting should also take place at the scanning center to allow for use of the same knowledgeable, familiar staff and, in the case where the seat is incorrect, a second imprint can be collected. At this time the fully finished product must be available to ensure not only the fit of the seat but also the accessibility of the vehicle. Any faults must be noted and the seat remade if it does not meet the exact requirements as it may be used to keep the child stable and safe. If the child is not able to tell the staff if the seat fits or if it is comfortable, there should be other equipment, such as a pressure mat, to check that there is a good pressure distribution to prevent discomfort from using the seat.

4.4.2 Scenario 2 – In-Store and Hospital Scanner “Vision”

This scenario would work in a very similar way to the previous scenario (i.e. In-store and Medical Scanning Center “Vision”) with the store purchasing time in a hospital facility rather than a scanning center.

4.5 Implants

The main point of customization for implants can only be at a hospital or a specialized center, i.e. scanning center, because it requires the use of specialist equipment such as MRI or CT scanners.

As it is, most specialist hospitals would already have equipment such as MRI or CT scanners. These equipments are usually operated by specially qualified medical personnel. Patients who require an implant will have to go to a specialist who either works for a public hospital or owns a private clinic. Since having and maintaining the scanning equipment is a high investment, private clinics might not have the facilities and the space for these equipments. In such cases, they can work with a hospital or a scanning center, buying time slots to use the scanning facilities. In either case, patients who need MRI or CT scan will be referred to the relevant department and book an appointment for the scan. The scanned results will then be sent to the respective doctor for analysis.

4.6 Prosthesis

The prosthesis case is very similar to the implants, except that it is possible to offer a home visit service for the patients.

4.6.1 Scenario 1 – Scanning Center "Vision"

As in the case for implants, a scanning center for the patients who need a prosthesis is likely to be the hospitals or prosthetic centers. Some private practicing prothetists might not have the scanning facilities in their premises, so in this case, they can buy time slots from either a hospital or a scanning center to use the scanning facilities. The scanning specialist will digitize the residual limbs of the patient and send the computer aided design (CAD) data to the respective prosthetist. The prosthetist will use the CAD model to design the socket and potentially the prosthesis for the patient. When the socket, and optionally the prosthesis, is ready the patient will go to the prosthetist for testing and rehabilitation.

4.6.2 Scenario 2 – Home Visits "Vision"

It is possible to introduce home visits service for patients requiring prosthesis, but only in cases where the patients require a replacement for their socket or the whole prosthesis. They will be able to make an appointment with the hospital for the home visits service. The team from the hospital will visit the patient to acquire the data for making the new socket and prosthesis. The data will be sent to the respective prosthetist to design the new socket prosthesis. The patient will have to visit the hospital or the prosthetist for the fitting. If the socket does not fit, the prosthetist can alter the socket design digitally and it is not necessary to arrange for another scanning.

5 DISCUSSION

The use of scenarios has enabled the identification of different possible points of customization. These scenarios have been identified through brainstorming. At the moment, only medical products are customized while the other consumer products studied in this project do not offer a customization service. The scenarios explore the different set-up for providing customization service from the customers' perspective. They attempt to "walk through" the process a customer is likely to have when they acquire customization service for a particular product. In each case, limitations and advantages of using the particular set-up has also been discussed.

The scenarios have highlighted a few issues which are involved with each set-up. Companies offering the customized products will have to look into their existing supply chain to decide where and how to offer these customized products, especially for the consumer products. Some of the manufacturers of these products sell through retailers and they do not control the retail chain. In such a case, the manufacturers need the support from the retailers and would have to provide the necessary training. Retailers need to be trained in assisting and advising the consumers in co-designing the products. They would also have to learn how to use the co-design toolkits. For both the manufacturers and the retailers, they will have to implement a new order tracking system to ensure that the right product gets to the customer. At the same time, both manufacturer and retailers have to implement a system to manage customer data. Such data will include not only personal information, but also body geometric, design preferences and product purchase information. For companies offering mobile and home visit services, they would need to invest new resources such as vehicles, trained personnel and scanning equipments. They will also need new logistical arrangement to provide such services.

From the scenarios, it can be seen that the point of customization for consumer and medical products varies from each other. Each product has its unique requirements and thus different point of customization. For the consumer products, it is important that the customization process give the consumers a good "shopping experience". Customization is not solely about services, it is also about value added product/service and an experience. From the advice of sales personnel on customization, to the scanning process right through to the delivery process and after sales customer service, consumers should feel confident that they are receiving value added products and services. A customization process is an information delivery and interactive experience. For example, in the case of mi-Adidas's customized running shoes, pressure distribution of the feet is checked and the sales personnel will explain what the pressure distribution means to the customers. The sales personnel will recommend suitable shoe cushioning for individual customer based on the pressure distribution chart. Customers gained new knowledge about their own body and interact with the sales personnel to find a pair of suitable shoes to fit

their activities and physique. They are also engaged in the co-design of the product [49]. As Pine and Gilmore [50] have aptly described, the consumers “have paid to spend time enjoying a series of memorable events that a company stages as in a theatrical play to engage him in a personal way”.

Consumer products are more likely to be able to engage their customers using different interfaces, including in-store, mobile services, scanning center, postal and Internet. The nature of the product and the level of customization available to the customers will affect the points of customization. The medical products (implants and prosthesis), on the other hand are limited to specialized scanning center and home visits. These products are specialized products which require specific knowledge and expertise. Moreover some of the equipment involved, such as in the case of implants, are expensive and require qualified personnel to operate them. The medical products are not as demanding for a ‘shopping experience’, although some privately owned hospitals or medical institution have tried to distinguish themselves by providing better services. Patients are more passive in the sense that they will not be able to act proactively in the design of the medical product. They have to rely on the expertise of the medical personnel. Patients requiring prosthesis and implants are already getting personalized products. Custom-Fit is proposing a new manufacturing method for the production of the prosthesis and implants, i.e. RM. While the patients may not necessarily be able to feel the difference in the product, it is the aim of the project to shorten their waiting time for treatment. To the patients, the most important criteria that they would have is improvement to their daily life. The main requirements for the medical products are to be able to produce the product faster and to be able to provide the service at a location which is convenient to the patients.

6 CONCLUSIONS

In conclusion, this paper has attempted to explain and show how scenarios have been used to identify the possible points of customization. These scenarios have been created under the anticipated possibilities for the point of customization. The scenarios are not elaborate and they can be further developed to look into issues such as the impact on the whole supply chain, human resources and business strategies. From the scenarios, a few management and logistical issues have been highlighted. These include the cooperation of retailers in providing customization service, provision of training and orders-tracking. Although this research has looked into only a few consumer and medical products, the different points of customization are applicable to other products. Many products have a similar situation while some require more specialized set-ups than others, especially the medical products and those used for the disabled. The medical products are restricted to little set-up while the consumer products will be able to have variations, depending on the nature of the product and the level of customization service available.

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