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Enabling Multidisciplinary Perspective in Student Design Project: Fast Fashion and Sustainable Manufacturing Systems

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Enabling Multidisciplinary Perspective in Student Design Project: Fast Fashion and Sustainable Manufacturing Systems

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Abstract:

Fast fashion retailers are growing faster than any other type of retailer due to their ability to offer trendy low-cost clothing mimicking latest runway trends with turnaround times as low as two weeks. Fueled by short production and distribution lead times, fast fashion retailers combine rapid prototyping, small batches of fashionable product designs, and efficient transportations and delivery. Among others, the methods applied in fast-fashion industry include mass customization and personalization, and lean manufacturing. Current trends in manufacturing lean towards the application of digital and rapid manufacturing methods and increased use of product lifecycle management, knowledge management systems and computer integrated manufacturing. Furthermore, modern fashion systems span geographical regions, wherein design and manufacturing is not necessarily done at the same location and it requires coordination of many pairs of hands and machines, followed by multiple processes and treatments to meet the demands of ever decreasing time-to-market. Hence, there are connections that can be used as a benefit for multidisciplinary student projects which would include fashion merchandising students and engineering students. Therefore, the purpose of this paper is to present a model of a project which would include a team of students with diverse backgrounds and experiences in fashion, engineering, and industrial technology in order to examine various manufacturing system concepts that can be used to enhance the sustainability of fast-fashion systems. These activities would be embedded in their current courses and they would expose engineering students to a fashion manufacturing industry and fashion students to engineering concepts of product lifecycle management and computer aided manufacturing. Special emphasis would be given to female engineering students who are not necessarily exposed to this kind of industry in their major.

Introduction

Fashion is impacting not only the clothing and accessories industry, but also automotive and consumer industry in a great extent and very frequently consumers develop complex emotional relationships with brands[1]. Furthermore, fashion trends are causing many of the changes in products which have a huge impact on engineering operations in many manufacturing companies. Similarly, engineering strategies such as Product Lifecycle Management (PLM) which are commonly used in the manufacturing industry are now being used in fashion industry[2].

Hence, understanding the basic principles of fashion and what different stages which are involved in decisions are related to different choices along the product design and development can be beneficial to engineering students. Product lifecycles are shorter in many different industries, from a car to an average cell phone, products are made in various different customized solutions and they are following the trends in the industry. Traditionally, it took six months for clothing retailers to bring couture fashions to consumer, but more recently the turnaround time has been compressed to a few weeks by fast-fashion retailers[3]. Fast-fashion, which refers to low-cost clothing collections mimicking latest runway trends flourishes on quick turnaround and agile supply-chains[3]. The ability of fast-fashion retailers' to capture the latest

trends and exploit narrow lead times to match supply with uncertain demand lends a greater incremental increase in profit than traditional retailers[4]. At the same time, they encourage obsolescence and disposability as they motivate shoppers to increase the frequency of store visits by offering trendy, low-cost and quality products[3]. Therefore, the fast-fashion supply chains are nimble yet the business model is unsustainable. For example, the extensive use of polyester and other synthetic fibers requires large amounts of crude oil and releases emissions such as volatile organic compounds and acid gases which can cause respiratory diseases[5]. Even the use of natural fibers such as cotton has environmental implications at the various stages of the product-lifecycle, including high use of pesticides to grow cotton, post-purchase consumption of significant amount of energy in washing and drying at high temperatures, and eventually disposing the product in lieu of a new trend available at the local fast-fashion store. In order to make an assessment of the environmental impact of fast fashion systems it is critical to systematically examine the opportunities, presented by modern green manufacturing methods. Accordingly, the purpose of this paper is to establish an educational model which could be implemented in engineering courses which was designed by faculties with diverse backgrounds and experiences in fashion, engineering, industrial technology and science education in order to examine various manufacturing system concepts that can be used to enhance the sustainability of fast-fashion processes.

Sustainability in Fashion Industry

In recent years, environmental sustainability has received considerable attention in the fashion industry. This is partially due to the use of significant amount of chemical products and natural resources across production processes[6]. A handful of retailers have made sustainability the forefront of their business philosophy, for example the clothing retailer Patagonia has the mission to "give the maximum attention to product quality while striving to do no harm to the environment" and only use organic cotton[7]. Some of the sustainable practices adopted by different retailers include reduction of energy consumption, reduction of waste and emissions, reduction of the environmental footprint of their products, and so on[8]. While each of these practices are notable, but it is important to consider the number of retailers that enforce them, for example in their study Mann et al. (2013) content- analyzed corporate websites of 17 top clothing retailers and found that only six addressed environmental practices on their websites. Additionally, the degree of commitment towards sustainability varies across the industry, for example in contrast to Patagonia's commitment to only use organic cotton, H&M notes that it uses organic cotton in 11% of it clothing. This may be in part due to the difficulty of enforcing sustainability in a global supply chain as searching around the world for lower production costs is a norm in the fashion industry[6, 9]. For instance, in 1992 an approximate 49% of all apparel sold in US was made domestically but by 1999 the number fell to 12%[10].

The inability of fast-fashion retailers to realize sustainability can also be attributed to high volatility, as it is characterized by frequent product introductions, supplier development, and process changes[11]. Environmental investments that work in other industries (e.g., paper, chemicals, and petroleum etc.) may not translate into operational efficiency into the fast-fashion industry[11]. Accordingly, mixed results have been reported regarding the benefit of environmental

investments in fashion industry. For example, while one study found that environmental investments do not pay equally in fashion industry[11], another reported that the use of established environmental management systems (EMSs) such as ISO 14000 improves profitability in the fashion industry[12]. In either case, it is important to survey the manufacturing literature to assess the applicability of various green manufacturing system concepts within the unique context of fast-fashion industry. In the following sections, we discuss various green manufacturing concepts that can be used to improve the sustainability of fast-fashion industry which is characterized by short production and distribution cycles, labor intensive global supply-chain, and significant consumption of chemical products and natural resources. Although fast-fashion retailers have nimble and efficient supply chains but the business philosophy in essence is unsustainable. Due to the quick-turnaround of the inventory, profitability is often based on the ability of the retailer to increase the frequency of customer visits, with some devoted customers visiting the stores every three weeks. Furthermore, low-cost and quality of the product encourages obsolescence and disposability, thus potentially leaving a significant environmental footprint. For example, the extensive use of polyester and other synthetic fibers requires large amounts of crude oil and releases emissions such as volatile organic compounds and acid gases which can cause respiratory diseases. Even the use of natural fibers such as cotton has environmental implications at the various stages of the product-lifecycle, including high use of pesticides to grow cotton, post-purchase consumption of significant amount of energy in washing and drying at high temperatures, and eventually disposing the product in lieu of a new trend available at the local fast-fashion store. Therefore, it can be beneficial to explore manufacturing concepts that can be utilized to increase the sustainability of the fashion industry. By designing projects and courses that expose fashion and engineering students to manufacturing concepts (e.g., rapid prototyping, reverse engineering, mass-customization and so on) will not only provide them with content knowledge of their discipline but will also allow them to critically evaluate various methods to execute sustainable solutions in the unique context of fashion industry. Below we discuss the various manufacturing concepts that can be incorporated in course projects that demonstrate methods of enhancing the sustainability of the fashion industry.

Rapid Prototyping and Reverse Engineering

Recent developments in computational power of modern computers which are used in industry have led to better integration of three dimensional data about various products and fabrics and easier capture of artistic creations to digital models[13]. Such digital models can further be used to manufacture and build prototypes which are used for evaluation and later for product development and manufacturing system design. Although these methods are widely used in industry, seldom there are educational applications of reverse engineering technologies which are embedded in courses which are dealing with engineering graphics. Hence, a need for integration of these methods into engineering and fashion curriculum might add a new perspective into fast fashion knowledge to both of these two diverse students groups. One of the applications of reverse engineering in clothing industry are 3D body scanners. In Figure 1, four kinds of measurements are shown which reveal much about body shape and clothing fit: volumes, surface areas, linear measures (circumferences), and slice areas (cross sections)[14]. The solution used for

developing a sizing system for clothing industry with a body scan technology was based on a software which was originally developed for the automotive industry, where 3D scanning is extensively used in design. Hence, if engineering students would have a project which would involve scanning their own bodies and developing a sizing system, not only that they would learn more about reverse engineering, but they would learn about technologies which are used in other industries which involve products with complex surfaces such as automotive, aerospace and defense.

Figure 1: Application of 3D body scanners in fashion industry[14]

Mass Customization and Personalization

Mass customization manufacturing systems are designed to enable personal approach to products and services[15]. They have to be designed carefully with real customer needs in mind, with not too many options which customers might sometimes find overwhelming. Online research methods such as data mining are used extensively to access consumer information and gather data which can be used to enable easier customization which would really fit the customer[16]. This kind of design approach is used in both, the fashion industry and engineering. Customers are looking for more product exciters than ever before and sometimes having something which they can adapt to their own personal habits may be the reason to make a purchasing decision or not. In addition, mass customization strategies, as shown in Figure 2, generate more sustainable products at lower cost and increased value[17] and increased value to the customer[18].

Figure 2: Mass customization in the fashion industry[17]

This kind of perspective is very well known to fashion students, but in engineering curriculum it is not emphasized in a great extent. . Considering that mass customization and personalization is becoming a norm in several industries, for example the automotive industry as as shown in Figure 3 Mini Cooper customers can chose design of their roofs with an online design tool[19]. Therefore, it would be beneficial to develop a course which would include these topics and would deal with engineering design theory embedded in fashion topics. In engineering terms, the project would include topics such as House of Quality, Group Technology, Parametric Design, Product Family, Bills of Materials, Bills of Manufacturing, flexible manufacturing and flexible assembly systems. Determining manufacturing as a flexible and fluid process which is adaptable to constant changes that are influenced by customer's opinion is one of the soft skills needed by industry of today

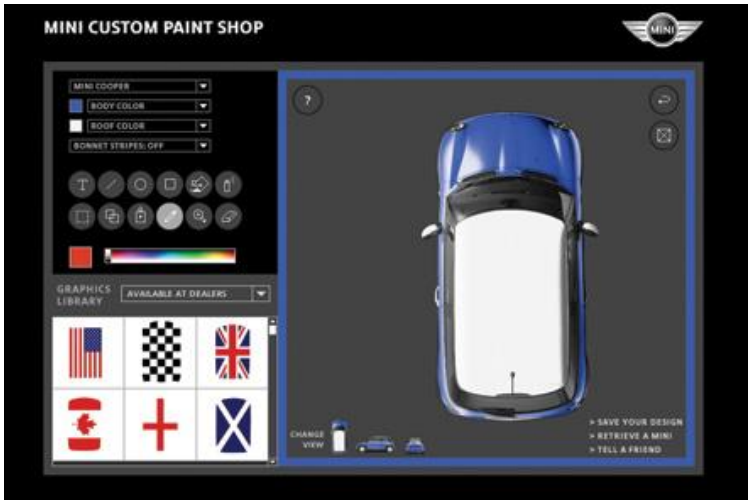

Figure 3. Personalization of Mini Cooper's roof in an online tool[19]

Green Manufacturing Systems

Recent changes related to various environmental regulations and regulative have posed pressure on manufacturers to deliver product in a more sustainable (greener) way. Clients, consumer groups and governments require increased attention to environmental performance of designs, processes, products and services[20]. Companies are required to track environmental related data along their supply chains and through the overall product lifecycle. These changes are happening slowly but are influencing various companies and their manufacturing processes. Costs related to the whole product lifecycle, not just the materials needed and manufacturing processes included are now in the center of the attention. Companies are trying to focus on all lifecycle stages of one product, what happens after the consumer is done with the use phase, what is going to happen when the products need to be disposed. They may be reused, remanufactured, or recycled. Some companies are implementing the environmental management system (ISO 14001) in the system of organizational management by embedding the tools for reducing adverse environmental impact and establishing green production in their informational systems in the company[21]. Sustainable development implies to the transformation of existing technologies to cleaner ones that see environmental sustainability as a prevention not as a

treatment. Evidence supports the need for manufacturers to develop information sharing and green information system capabilities to improve environmental performance[22]. Example of the green manufacturing strategy is outlined in Figure 4[23].

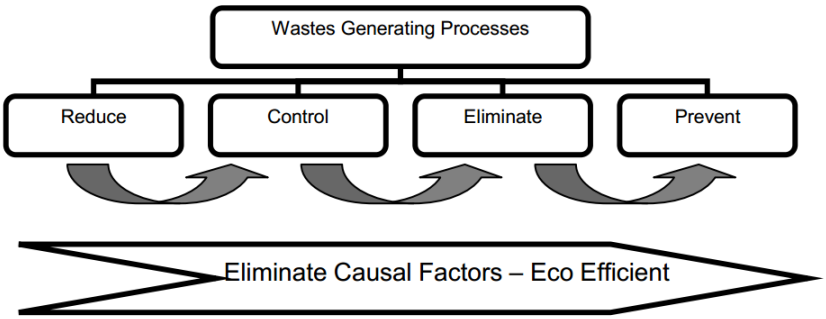

Figure 4: Green manufacturing – waste generating processes[23]

Lean Manufacturing

This manufacturing strategy focuses on waste elimination as method to increase profitability in manufacturing and distribution businesses[24]. By lean manufacturing methodology, it essential to identify wastes and to know what causes them and how can they be eliminated. Activities which are adding value have to clearly be distinguished from those which are not adding value to the product[25]. Engineering students do take courses in lean manufacturing in which they learn basis about this business strategy and manufacturing philosophy. Fashion students could also learn about seven wastes such as: overproduction, waiting times, transportation and handling, useless and excess inventories, production process, useless motions, and scrap and defects. All of which are also important in fashion industry as various countries have started to practice lean tools in the garment industry and observed tremendous improvement[26].

Engineering Students and Fashion Merchandising Student Design Project

A multidisciplinary project in which engineering students could work on a whole product lifecycle development of one fashion item wound integrate multiple perspectives, such as: sustainability, high turnover rates (very typical for many products which are being manufactured today), mass customization, green manufacturing, and lean manufacturing. This one semester long project would include two design courses, one from Fashion Merchandizing and other from Engineering Design area. Students would be given a task to design a sustainable product which could be manufactured on a Rapid Prototyping machine. The teams of two engineering and two fashion merchandising students would be formed. They would be asked to design a product and plan for its manufacturing, assembly, service, disposal, and recycling. In this way engineering students would learn from fashion merchandising students about different issues related to supply chain, purchasing, ordering etc. and fashion merchandising student will learn about the cycle of product design and development.

Figure 4: Rapid prototyping with Maker bot and a fashion item build with 3D printing[27,28]

Conclusion

Each of the manufacturing concepts discussed above can be used to design projects that expose students to content that encourages them to critically evaluate and derive sustainable solutions for the fashion industry. For example, by designing a team project that involves fashion and engineering students in design and realization of a customizable fashion item (e.g., jewelry) can be used to reinforce manufacturing concepts such as principles of lean manufacturing, reverse engineering, mass customization, and so on. In such a project, each student design and realization team can include students from fashion, industrial technology and from engineering to foster multidisciplinary nature of industry work in a classroom through hands on activities and project based learning (PBL). Students can be allocated tasks to design new products with given constraints and limitations, to build a prototype from play dough, clay or wood, use reverse engineering methods to capture the design intention. Following which they can design product for mass customization, with the necessary variants. In such a project students can use be exposed to the House of Quality tool to research about possible competitors, perform benchmarking, survey random participants about customer expectations, in order to learn to transfer customer expectations to engineering parameters and develop design constraints. Finally, students can be allocated tasks to manufacture a workable prototype using rapid prototyping technology. We believe that projects such as the one described above can be used to enrich the existing curriculum by encouraging critical thinking and problem solving in a multidisciplinary context.

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