CORLEONE DANCEWEAR

Sustainably sourced, ethically produced dance apparel

http://www.bdsdancestudios.uk/discover-dance/ballet/

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1. Systems Map and Current State of the Art

It is estimated that there are 300,000 dancers[1] in the US that wear leotards regularly. Dancers usually have between 1 and 20 leotards, though professionals can have more than a hundred. Depending on the material, use, and care, dance leotards are sometimes only used for a few weeks or months before they are thrown out.

Problem Statement:

Currently, the non-biodegradability of high-impact petroleum-based leotards renders most dance leotards unsustainable[2]. A leotard's negative environmental impact can be attributed to material waste from fabric and energy usage from washing. Additionally, leotards can fall under the same problems inherent in 'fast fashion', where consumers only use their leotard for a few weeks or months before they wear out and end up in the landfill. There is little information available about the materials that go into dance leotards currently. Corleone aims to provide dancers with sustainable leotards, while also providing greater transparency regarding the cradle-to-grave impact of the leotard.

Current SOA:

Most leotards are made with lycra/spandex blends, nylon, polyester, or cotton. There is generally no end of life plan, so most leotards end up in a landfill. This is largely due to the blending of the textiles and the textile processing. The dancewear market in 2017 was at $450 million and is projected to reach $530 million in 2023, growing at a rate of 4.5% per year[3]. Currently, the top market players are Capezio, Bloch, and Leo Dancewear[4] – none of which have a focus on sustainability.

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[1] https://www.researchgate.net/publication/263693909_The_Demographics_of_Dance_in_the_United_States
[2] https://www.fabric.com/buy/0450616/nylon-lycra-spandex-athletic-knit-solid-red
[3] https://www.whatech.com/market-research/consumer/563593-global-dancewear-market-2019-size-share-sales-channel-distributors-traders-dealers-appendix-and-data-source-to-2023
[4] https://www.thoughtco.com/online-dancewear-1006947

Whole Systems Map:

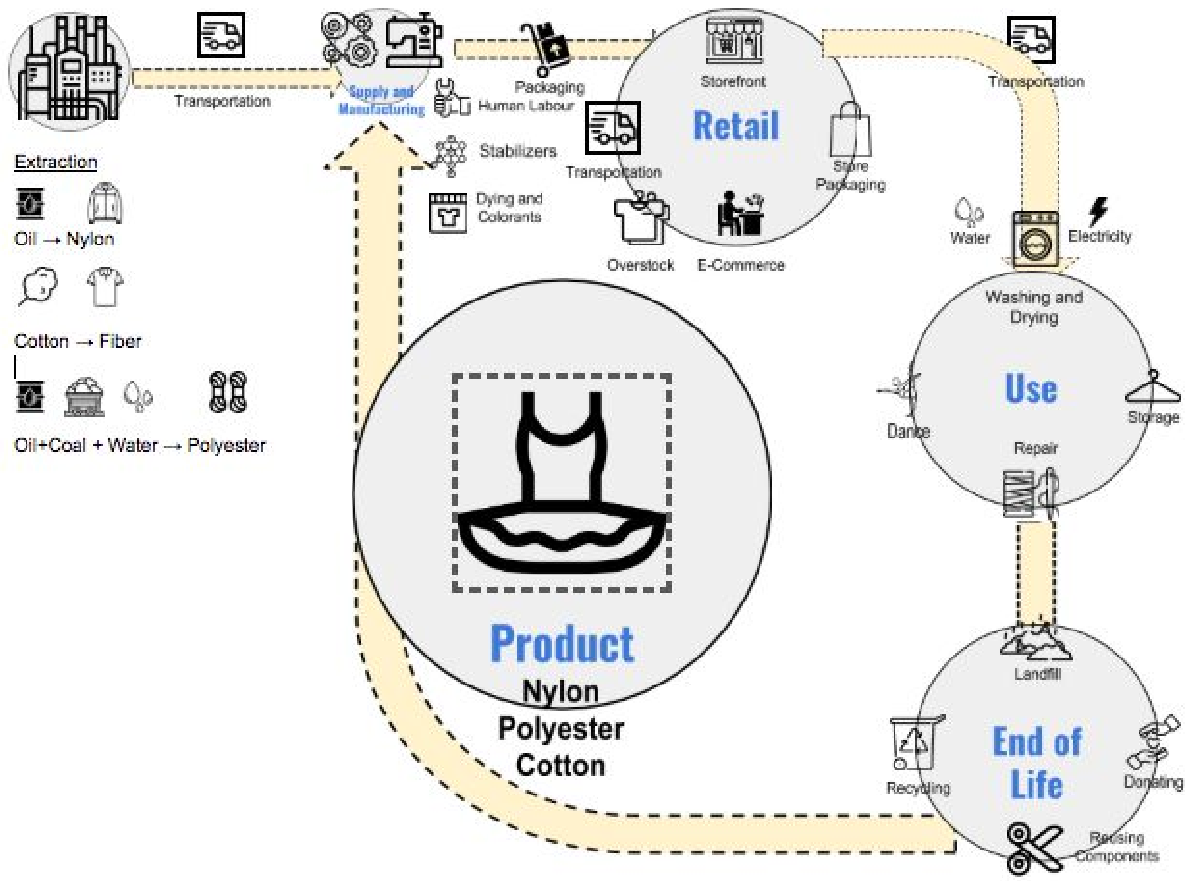

Fig. 1.1 Systems Map

The systems map gives a visual representation of the individual components that make up the life cycle of the leotard, as well as their interactions with one another. Our systems map shows the cyclical nature of the life cycle of a leotard, from extraction of the base materials, to the end of life where leotards are either recycled or disposed of. The whole systems map gave us insight into the areas of overlap and impact in our product's life cycle, as well as the exterior inputs that affected the life of the product, such as water and electricity from washing.

The life cycle of of a leotard begins with the extraction of raw materials, such as crude oil, cotton, and water[5]. These are then converted into textiles, such as cotton fiber, polyester, and nylon, that are used in the creation of the leotard. These materials are transported to the factories, where they are made into clothing. This process includes dying, adding stabilizers, and human labour[6, 7]. We chose to include

[5] http://www.craftechind.com/how-is-polyester-made/
[6] https://uniqueleotards.wordpress.com/
[7] https://sewport.com/how-clothes-are-made

human labour, because as part of our mission to be a more sustainable and transparent textile company we wanted to be mindful of our workforce as well. These clothes are then packaged and shipped to their next destination, which is either a warehouse, store, or company storage unit. They then are purchased by the customer, which initiates the process of repackaging the clothes, shipping them out again, or transporting them to the home of the person. At the person's home the product is used, stored, and washed. Some users will also do their own repairs, mending their leotards[8]. The majority of use is dancing and washing, after which the product begins to deteriorate. We found that some people then donate their used leotards, or throw them away[9]. Even fewer recycle them, due to the fact that most of these products are non-recyclable, or reuse their component parts. Those leotards that are recycled or donated begin the cycle anew, entering in at the manufacturing or use phase respectively.

[8] https://www.mamapedia.com/article/how-can-i-fix-a-hole-in-a-dance-leotard
[9] https://www.dancespirit.com/pointe-ing-greener-world-2326515507.html

2. Design Brief

Boundary and Functional Unit:

Boundary: We chose to focus on the sourcing of materials, as measured by Sustainable Minds, through the life of the product. This covers the manufacturing, transportation, use, and end of life. We chose not to include packaging as this was not a factor that our client wished us to consider. Rather, we chose to put our energy towards the cradle and grave areas of the product.

Functional Units: This led us to choose a functional unit of 1 hour. We chose 1 hour because the time a leotard is used can be measured in hours, which can then be multiplied based on a variety of other factors: washing time, dance time, and lifetime.

Original Weighting Priorities:[10]

1. LCA Score: While the LCA score is important and essential to give a snapshot of the product's environmental performance, it is not extremely useful for analyzing materials' performance. Hence, LCA score has been weighted as 3.
2. Reduction of Total Energy Used when Washing: the electricity consumption by the washing machine is the largest environmental impact. Hence, this parameter has been given a weight of 4. We would like to alter the leotard such that it requires no machine washing or less frequent washing. We will not be redesigning a washing machine.
3. End of Life Potential: is the leotard recyclable, compostable, reusable, or does it need to be sent to a landfill at the end of its life? Our client would ideally like the leotards to be compostable or, at the very least, have minimally impactful end of life. Hence, the end of life potential of a leotard has been weighted as 4.
4. Flexibility, Comfort, and Appearance: In order for the Corleone leotards to be competitive, they must meet or surpass the current state-of-the-art in flexibility, comfort, and appearance. Irrespective of the product's quality, it is ultimately customers who drive the market. Hence, the three factors which determine user experience have been given a high weight of 4.
5. Price: Similarly, we would like to keep the costs of the Corleone leotards consistent with industry standards, so that consumers will buy the products. Hence, an LCA score of 3 has been assigned.

New Weighting Priorities:

1. Sustainable Materials Make up 70% of Leotard: It was important to us, and our client, that we use materials that are made from recycled material, or renewable resources, and that are third party certified as sustainable. We realize that to attain the qualities required in a dance leotard there

[10] As we developed our designs and worked more closely with our clients, our priorities and their respective weightings evolved throughout the term. The Original Weighting Priorities correspond to those outlined in our initial design brief.

needs to be some synthetic material used, due to the current state of textile technology. However, we think that we can get a majority of our leotard to be made of a “sustainable” material

2. A Majority of the Leotard can be Recycled, or Repurposed: Another important component of the leotard to our client, we wanted to divert them from landfills. Currently a majority of leotards end up in the trash, and so we wanted to differentiate our leotard from the rest. This means that the textiles used can be recycled, and that the colorants and chemical finishes to them can either be removed, or are non-toxic.
3. Novelty of Product: We know that to compete in a market such as clothing design there needs to be something unique and “new” to our product. We therefore weighed the necessity of creating a product that has a newness to it.
4. Solution Reduces Energy in Use Phase by 50%: The majority of impact in the life of a leotard is during the use phase, and comes from the energy associated with washing the product. Therefore, we wanted a leotard that reduces this impact a lot. While our client did not see this a priority, we thought it important to weigh this as a priority due to the large difference a lower energy use has on the product.
5. LCA Scores: We used the LCA score as a metric for the general sustainability of our product. We realize that there is a lot of uncertainty involved in our LCAs, especially due to the minimal nature of the database. But, we wanted a general metric to weigh all of our options against one another.
6. Price is Competitive with other Dancewear Companies: It was important to us to have a leotard that was competitively priced, otherwise we would not be able to get people to buy our product in the first place. Competitive pricing for dance leotards falls anywhere between $70-$100.

3. Illustration of Winning Idea

Fig 3.1 Repreve and Antimicrobial Treatment

This design combines two existing, commercially available technologies. REPREVE® is a performance fiber made from recycled materials, including plastic bottles.[11] Because REPREVE® feels like standard high-performance fabric, it does not compromise user experience. Many reliable athletic wear brands such as Patagonia, Volcom, and Quiksilver use REPREVE® in their products.

The antimicrobial treatment we intend to use is Polygiene®. Polygiene® prevents the growth of odor-causing bacteria by using low concentrations of silver chloride, which has antimicrobial properties.[12] Polygiene is made out of completely recycled silver from electronics (outsources this to a recycling-only company), increasing its sustainability. Polygiene can also be removed from textiles, making the separation and subsequent recycling of leotards more feasible. Patagonia treats some of their underwear and base layers with Polygiene, and testers have claimed that Polygiene® successfully prevents bad odors even after a week without washing.[13,14] For this reason, we believe that treating our leotards with polygiene would allow dancers to wash their leotards 50-75% less, thus saving significant energy and reducing the leotard's environmental impact.

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[11] https://repreve.com/
[12] https://polygiene.com/
[13] https://www.bicycling.com/bikes-gear/a20047916/does-polygiene-work/
[14] https://gearjunkie.com/stink-test-patagonia-polygiene-boxers

4. Sketches of Finalists

Return and Mend Program for used leotards

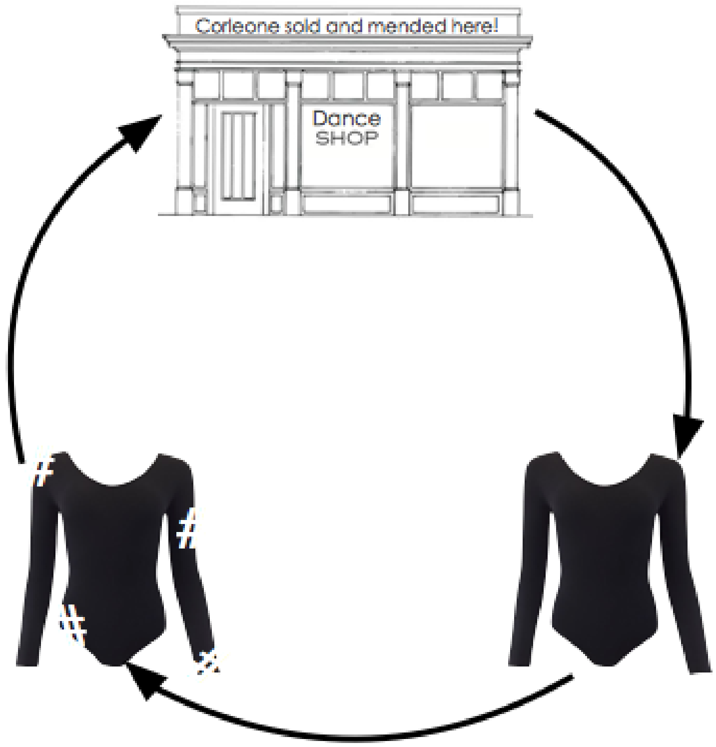

Fig 4.1 Return and Mend Used Leotards

Dancers go through leotards very fast. One major reason could be that once ripped, they are difficult to mend it, without the proper know how. Also, as leotards wear out, the repair process can be confusing to consumers. If we were to have a complimentary mending service, we could have professionals with the proper textiles and materials mending leotards. Corleone's mending service will help solve this problem and increase the lifetime of leotard, some estimates have this number as high as 2 years, but realistically a leotard could last anywhere between 5 months and a year longer[15,16].

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15 http://www.dance.net/topic/10132620/1/Ballet-General/Let-s-chat-how-long-do-your-leotards-usually-last-you.html

16 https://www.thespruce.com/how-to-care-for-dance-costumes-2145793

Cleansing wipes for leotard

Fig 4.2 Cleansing Wipes Solution

The leotards greatest environmental impact comes from washing the leotard: both in terms of the electricity used and the water required. We ideated to try to combat the high impacts of washing. One of our ideas was to have a cleansing wipe that we sold along with the leotard, which would allow users to wipe down their leotards instead of throwing them in the washing machine. Though this would incur additional impacts from the production and processing of the wipes, it completely eliminates washing, and thus drops the carbon footprint in the use phase to zero. The wipes would be made from cotton and chemicals such as sodium and potassium salts which have cleansing properties and are common components of detergents. In addition to completely eliminating water and electricity consumption during use phase of the product, it also reduces overall TRACI impacts by 15%. Thus, by eliminating the need for washing and drying, cleansing wipes make it easier for users to adapt a more sustainable lifestyle.

Salad spinner washing solution

Fig 4.3 Salad Spinner Washing Solution

The salad spinner washing method aims to reduce the impacts of the washing of the leotard. There are many existing DIY videos explaining how to wash clothes with a salad spinner[17], which both reduces the energy required for the washing machine (though there is still energy in the heating of the water) and is a gentler way to wash leotards, potentially increasing the lifetime of the leotard. While innovative and effective, the salad spinner does cause slight inconvenience to customer. However, for the dancer on the go, or for the individual who cares about their electricity bill, a salad spinner is a great option. The salad spinner functions through the user's own energy supply, saving them electricity, as well as the amount of water used in a conventional washing machine, between 10-40 Liters of water[18].

[17] https://www.youtube.com/watch?v=JjlnWWM6PPQ
[18] https://www.salon.com/2013/10/09/green_swag_the_modern_hand_operated_laundry_machine/

Energy conserving dance floor

Fig 4.4 Energy Conserving Dance Floor

Energy capture mechanism might be difficult to implement and also has a lot of uncertainty associated. Energy capturing dancefloors capture the kinetic energy produced through movement (dance!) and convert it into electricity, that can be used to offset some of the power usage, and specifically, washing of leotards, of dance studios. The system functions using a rack and pinion system that translates the up and down movement of dance into an electrical difference that is stored in a battery in the panel. The panels can store between 5 and 30 Watts of energy per person[19], in some applications providing enough energy to charge cellular devices. In theory this technology could be expanded to provide energy for washing machines in situ, allowing dance companies to wash their leotards with little to no energy impacts. Current applications are based on visual cuing, however the amount of energy required to run an Energy Star washing machine is on average 500 watts[20]. If you had 20 students in a dance class, for 10 hours of classes a day, the energy produced could easily power a washing machine through multiple cycles.

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[19] https://www.energy-floors.com/sustainable-dance-floor/
[20] https://www.energystar.gov/products/appliances/clothes_washers

GreenShield Finish

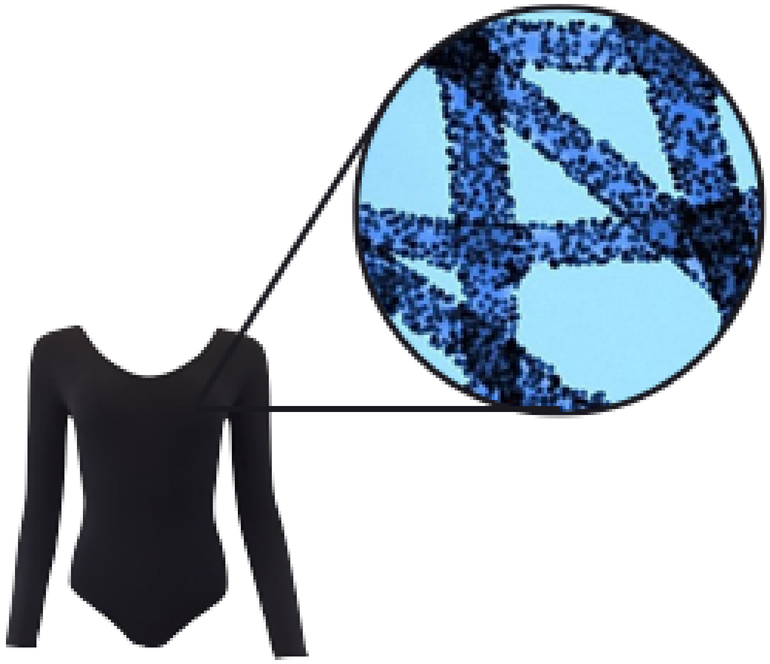

Fig 4.5 GreenShield Finish

GreenShield is a finish that mimics the water repellent structure of the lotus leaf. It is water, oil, and stain resistant. GreenShield, therefore, would reduce the need for washing the leotard as it is less likely to become dirty. GreenShield is a proven fluorocarbon reduced application that has been tested rigorously by the company and third party candidates.[21] GreenShield differs from other finishes by acting as an attachment, locking into the fabric, rather than creating a non-breathable polymer layer that covers the original textile layer. It is also stain resistant due to the biomimetic properties of the finish - a simple brushing and lathering removes stains, rather than a more intense chemical process. Greenshield also keeps color strong, rather than reducing the sheen of textiles that it covers, making it an appealing finish for performance leotards.

[21] https://greenshieldfinish.com/

Worn Wear Website

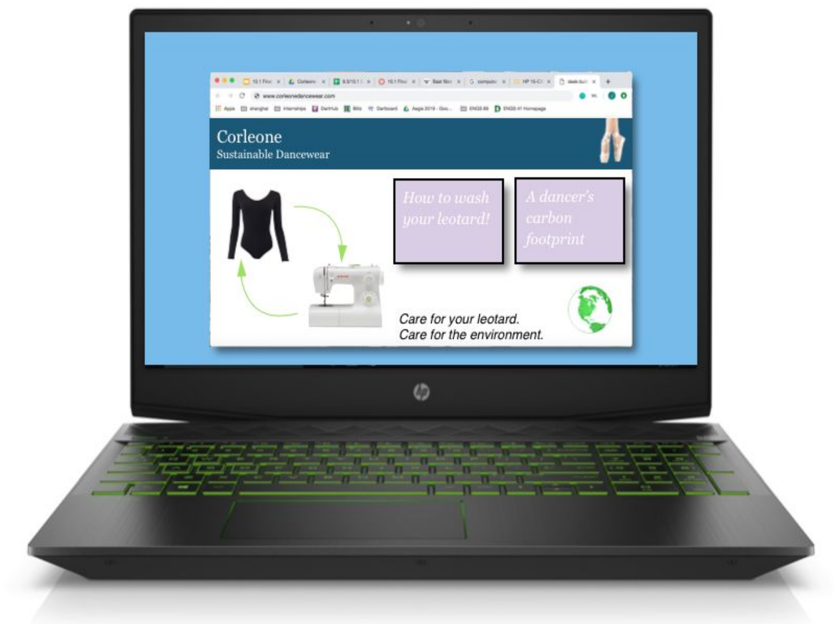

Fig 4.6 Worn Wear Website

The worn wear website is an additional service that will be provided with the final design of sustainable leotard and hence was not considered as a top three recommendation. This service based solution would help to change user interaction with the product, as well as offer solutions during the use phase, the area of most energy use, to consumers. This would also help to create brand loyalty and a community that could interact online. Worn Wear campaigns are few and far between, however major clothing companies have shown success in this arena. Patagonia has changed the culture of outdoor wear by increasing reuse by 50% on their products, and they've also created a culture of DIY fixing through helpful guides related to their clothing[22] [23].

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22 https://wornwear.patagonia.com/

23 https://www.eastbaytimes.com/2008/12/03/joans-world-what-happens-to-the-dancing-costumes-after-theyre-worn/

5. LCA comparisons

Finalist ideas were evaluated based on design, environmental and business priorities.

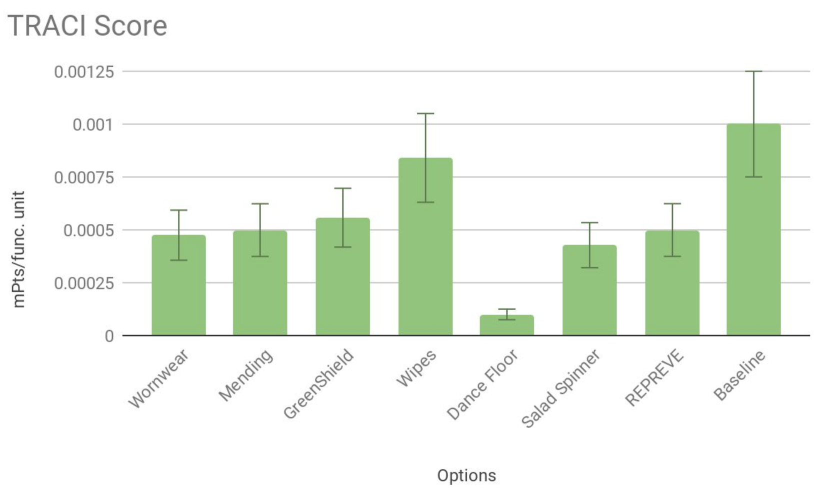

Fig 5.1 TRACI Score Across Options

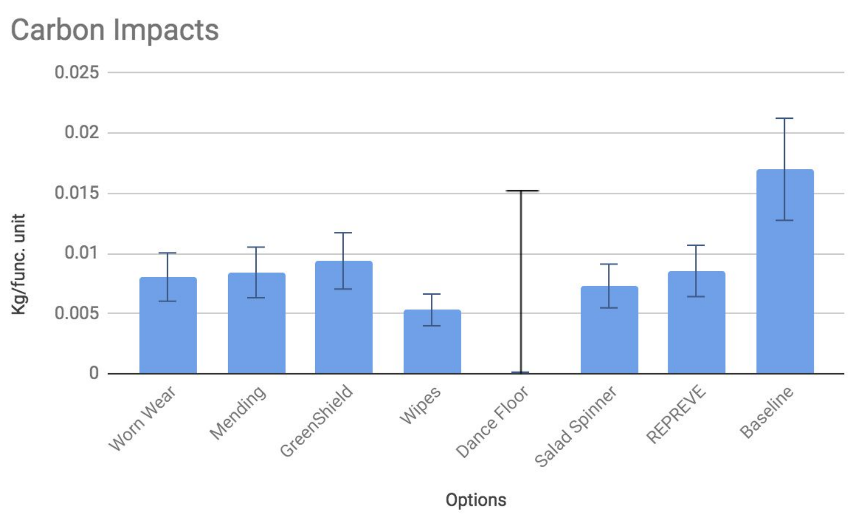

Fig 5.2 CO2 Impacts Across Options

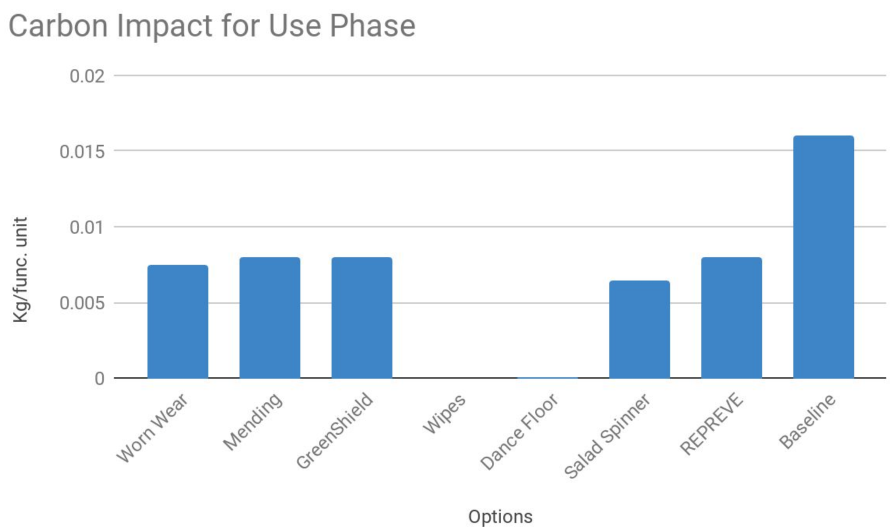

Fig 5.3 CO2 Impacts by Use Phase

Fig. 5.1-5.3 evaluate finalist ideas using different metrics and show how they performed against each other. These results are from the LCAs performed on ‘Sustainable Minds’. The results are an approximation because of lack of accurate information and substantial alternatives in their database which led us to make calculated assumptions. These assumptions have been elaborated in the appendix, and accounted for in final LCA results. For example, energy capture from dance floor seems to have the least impact, however it was the option with the most uncertainty. A similar pattern was observed in the TRACI score analysis. The ‘use’ phase analysis showed some interesting results. As you can see, wipes and dance floor have a ‘zero carbon impact’. This is because wipes eliminate the need for water and electricity during the ‘use phase’ and their impacts were accounted for in the manufacturing phase. Hence, the overall carbon impact offers a better picture of the results for each option.

6. Decision Matrix

Priority	Weight	Worn Wear	Return and Mend	Repreve & anti-microbial	Salad Spinner	Leotard with cleaning wipes	Leotard with Green Shield	Dance Floor Energy Capture
LCA impacts	1	3	3	3	3	2	3	5
Energy reduction	3	3	3	5	4	5	4	5
EOL Treatment	5	5	5	3	3	3	2	4
User experience	5	4	4	4	2	4	2	4
Client preference	4	3	3	5	2	3	4	1
Price	4	3	3	2	3	2	2	1
Wow factor	4	3	3	5	3	3	5	5
Total		93	93	101	72	84	79	88

Fig 6.1 Decision matrix using design priorities

A design matrix was used to evaluate finalist ideas based on design priorities. We gave 'End of Life treatment' the highest weighting as this is the stage of the leotard lifecycle that we have the largest ability to controllably change: we can produce an easy recycling system and prevent leotards from ending up in landfills. Our business and design priorities include having recyclable and/or biodegradable materials. 'User experience' is also given the highest weightage because this is extremely crucial in a leotard. The next three factors in order of importance are client preference (based on what Caroline had told us she wanted to focus on), price (upfront price for the user) and the 'wow' factor associated with each idea (if the consumer would be excited about this new possibility). LCA impacts are given the lowest weight to avoid double counting some of the priorities that were already considered, and also to acknowledge the uncertainty associated with LCAs (especially because the textile data on Sustainable Minds was not very accurate). Based on the above evaluation, our top three choices were **1) REPREVE and anti-microbial fabric**, **2) return and mend business model**, and **3) cleaning wipes**.

7. Final Ideas

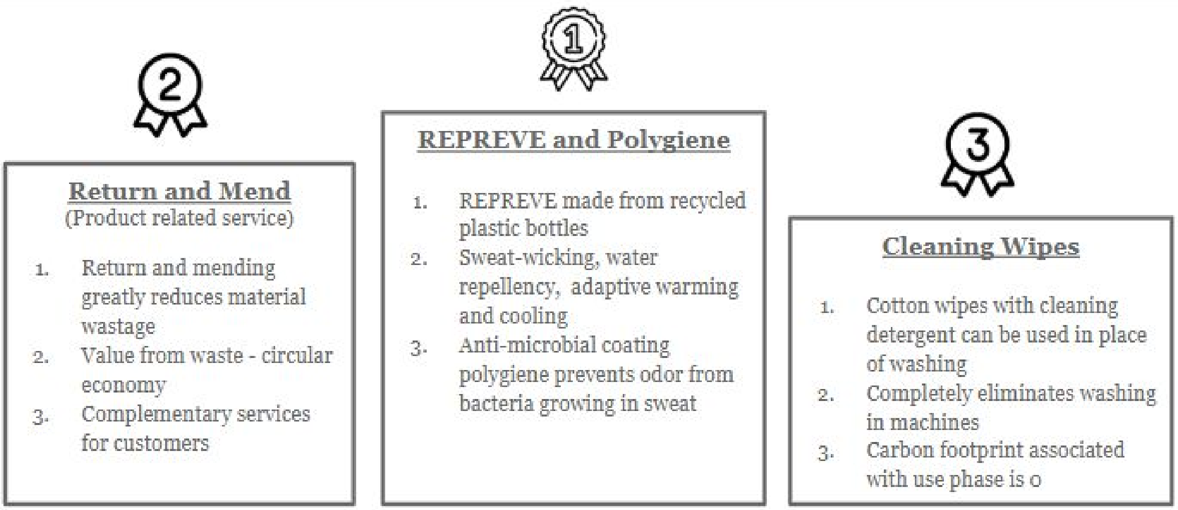

Fig: 7.1 Top three recommendations

Based on assessments of finalist ideas, through the design matrix, we chose the options shown in Fig 7.1.

1. **REPREVE** is made from recycled plastic found in oceans. This enables waste from plastic bottles to re-enter the value chain, thus reducing waste. When coupled with polygiene which is anti-microbial and odour-block coating, leotards need less washing, and therefore use less water and energy during the life of the product. The polygiene treatment can be removed from the leotard at EOL, and therefore would be easy to recycle, meeting our design priorities.

2. **Return and Mend service** increases the lifetime of a leotard and aids in value creation from waste. Additionally, the return and mend service would improve our customer relationships, resulting in a dedicated consumer base.

3. **Cleansing wipes** eliminate the need for washing leotards in washing machines, and hence greatly reduce energy and water costs associated with the product. However, due to the impact of manufacturing paper and additional chemicals, this option was not scored as highly REPREVE/Polygiene or the Return and mend service.

8. Conclusion

The final report and presentation, and the process involved in brainstorming ideas and finalizing priorities, aid in green product innovation by persuading designers to think of products that are both financially and environmentally feasible. This iterative process polishes existing solutions and broadens their scope by including complementary services and products to enhance user experience. Unless a product is able to compete with existing market products on all fronts such as cost and ease of availability, there is very little likelihood that a customer will actually opt for it.

This class introduced us to a series of paradigms that help to give perspective to the questions around sustainability and the life of a product. The toolkit that we established throughout this course not only helped to create a string of ideas for our final product, but also to frame other products and business models in the context of sustainability and their overall impact on the world. We also learned that through collaboration, and actively engaging with one another's concepts, that we could push the envelope way further on ideas and solutions. Each exercise was a chance to improve not only our product, but our ability to perform these thought processes for a variety of industrial ecologies. We also utilized the readings to help situate ourselves better for the activities. For instance, the twelve leverage points, as listed by Donella Meadows[24], aided a ton in establishing areas of emphasis for our project, as well as thinking critically about product cycles generally. Overall, we gained a ton of practical and theoretical knowledge that will be sure to serve us in whatever career paths we take, as well as help us to pinpoint areas of change we can focus on in future entrepreneurial endeavours.

[24] http://donellameadows.org/archives/leverage-points-places-to-intervene-in-a-system/

Appendices

Total = $1.0x10^{-3}$ mPts/func unit

	Input	mPts/func unit
	Electricity, 120 V, US	$9.33x10^{-4}$
	Nylon 66	$2.08x10^{-5}$
	Tap water, at user	$1.90x10^{-5}$
	Polyester fabric	$1.19x10^{-5}$
	Textile refinement, cotton	$4.42x10^{-6}$
	Injection molding, plastics	$3.97x10^{-6}$
	Truck and trailer	$2.63x10^{-6}$
	Truck and trailer	$1.02x10^{-6}$
	Truck and trailer	$1.82x10^{-7}$
	Landfill, plastics, mixture	$1.41x10^{-7}$

Total = $4.7x10^{-4}$ mPts/func unit

	Input	mPts/func unit
	Electricity, 120 V, US	$4.35x10^{-4}$
	Nylon 66	$1.39x10^{-5}$
	Tap water, at user	$8.89x10^{-6}$
	Polyester fabric	$7.92x10^{-6}$
	Textile refinement, cotton	$2.95x10^{-6}$
	Injection molding, plastics	$2.65x10^{-6}$
	Truck and trailer	$1.76x10^{-6}$
	Truck and trailer	$6.78x10^{-7}$
	Truck and trailer	$1.21x10^{-7}$
	Landfill, plastics, mixture	$9.37x10^{-8}$

Fig A.1 Worn Wear TRACI score

Total = 0.017 CO_2 eq. kg/func unit

	Input	CO_2 eq. kg/func unit
	Electricity, 120 V, US	0.0158
	Nylon 66	$3.92x10^{-4}$
	Tap water, at user	$2.47x10^{-4}$
	Polyester fabric	$2.28x10^{-4}$
	Injection molding, plastics	$8.42x10^{-5}$
	Textile refinement, cotton	$6.46x10^{-5}$
	Truck and trailer	$3.56x10^{-5}$
	Truck and trailer	$1.38x10^{-5}$
	Landfill, plastics, mixture	$4.51x10^{-6}$
	Truck and trailer	$2.46x10^{-6}$

Total = 0.0080 CO_2 eq. kg/func unit

	Input	CO_2 eq. kg/func unit
	Electricity, 120 V, US	0.00737
	Nylon 66	$2.61x10^{-4}$
	Polyester fabric	$1.52x10^{-4}$
	Tap water, at user	$1.15x10^{-4}$
	Injection molding, plastics	$5.61x10^{-5}$
	Textile refinement, cotton	$4.31x10^{-5}$
	Truck and trailer	$2.38x10^{-5}$
	Truck and trailer	$9.17x10^{-6}$
	Landfill, plastics, mixture	$3.01x10^{-6}$
	Truck and trailer	$1.64x10^{-6}$

Fig A.2 Worn Wear CO2 score

Name	Consumables/water/power	Amt	Unit	mPts	CO_2 eq. kg	MS	
Consumables				0	0		Add Consumables +
No consumables have been added to this SBOM.							
— Water use				0.0555	0.720	E	Add Water Use +
Water	Tap water, at user	437	gal	0.0555	0.720	E	
— Power use				2.72	46.0	E	Add Power Use +
Power	Electricity, 120 V, US	54.6	kWh	2.72	46.0	E	
30% reduction in use, conservative number based off of a study done by a governmental agency in England of the entirety of the country. Electricity source as 120 V to account for general outlet voltage in an American home.							
	Use total			**2.77**	**46.7**	**E**	

Fig A.3 SBOM Differences in Use Phase Worn Wear Option

The water and power usage during the life of the product is significantly reduced during the life of the product, This is due to the increased knowledge of the user, as well as the increased lifetime of the product. A worn wear website would inform the user about methods to maintain their leotards for longer, as well as ways to mend their products, and contact other users who do the same. We assumed that the worn wear program would work similarly to Patagonia's, that the lifetime of the product would be improved, that the amount of energy used in the product would be decreased by the increased knowledge of the consumer, and that people would willingly use our site.

Total = $1.0x10^{-3}$ mPts/func unit

Input	mPts/func unit
Electricity, 120 V, US	$9.33x10^{-4}$
Nylon 66	$2.08x10^{-5}$
Tap water, at user	$1.90x10^{-5}$
Polyester fabric	$1.19x10^{-5}$
Textile refinement, cotton	$4.42x10^{-6}$
Injection molding, plastics	$3.97x10^{-6}$
Truck and trailer	$2.63x10^{-6}$
Truck and trailer	$1.02x10^{-6}$
Truck and trailer	$1.82x10^{-7}$
Landfill, plastics, mixture	$1.41x10^{-7}$

Total = $5.0x10^{-4}$ mPts/func unit

Input	mPts/func unit
Electricity, 120 V, US	$4.66x10^{-4}$
Nylon 66	$1.04x10^{-5}$
Tap water, at user	$9.52x10^{-6}$
Polyester fabric	$5.94x10^{-6}$
Textile refinement, cotton	$2.21x10^{-6}$
Injection molding, plastics	$1.99x10^{-6}$
Truck and trailer	$1.32x10^{-6}$
Truck and trailer	$5.09x10^{-7}$
Truck and trailer	$9.08x10^{-8}$
Tanker, oceanic	$5.49x10^{-8}$

Fig A.4 Mending TRACI score

Total = 0.017 CO_2 eq. kg/func unit

Input	CO_2 eq. kg/func unit
Electricity, 120 V, US	0.0158
Nylon 66	$3.92x10^{-4}$
Tap water, at user	$2.47x10^{-4}$
Polyester fabric	$2.28x10^{-4}$
Injection molding, plastics	$8.42x10^{-5}$
Textile refinement, cotton	$6.46x10^{-5}$
Truck and trailer	$3.56x10^{-5}$
Truck and trailer	$1.38x10^{-5}$
Landfill, plastics, mixture	$4.51x10^{-6}$
Truck and trailer	$2.46x10^{-6}$

Total = 0.0084 CO_2 eq. kg/func unit

Input	CO_2 eq. kg/func unit
Electricity, 120 V, US	0.00789
Nylon 66	$1.96x10^{-4}$
Tap water, at user	$1.24x10^{-4}$
Polyester fabric	$1.14x10^{-4}$
Injection molding, plastics	$4.21x10^{-5}$
Textile refinement, cotton	$3.23x10^{-5}$
Truck and trailer	$1.78x10^{-5}$
Truck and trailer	$6.88x10^{-6}$
Truck and trailer	$1.23x10^{-6}$
Tanker, oceanic	$6.61x10^{-7}$

Fig A.5 Mending CO2 score

Impacts per functional unit	$5.0x10^{-4}$ **mPts per 1 hour of use**
Total amount of service delivered during the lifetime of the product	8320 x 1 hour of use
Impacts of total service delivered	4.1 mPts
Assessment level	Estimate
Methodology	SM 2013

Greatest impacts

SBOM input	Electricity, 120 V, US
Impact category	Carcinogenics
Life cycle stage	Use

Fig A.6 Lifetime Impact of Mending Option

Name	End of life method	Qty	Amt	Unit	mPts	CO_2 eq. kg	MS	Part ID
Nylon		1	0.45	lb	0	0	E	
Material	Nylon 66		0.449999	lb			E	
Process	Recycling		0.449999	lb	0	0		
Spandex		1	0.1125	lb	0	0	E	
Material	Polyester fabric		0.112499	lb			E	
Process	Recycling		0.112499	lb	0	0		
	End of Life total				–	–	E	

Fig A.7 SBOM End of Life Mending Option

The mending leotards option has a difference in end of life. This is due to the fact that overtime the leotard uses less energy over its lifetime by simply existing for longer, as well as the fact that the product is reused overtime by other users. Roughly a 9 month increase in the lifetime of the product is possible by mending and maintaining leotards throughout their life. This statistic comes through research on forums around saving dancewear, studies done by the British organization WRAP[25], and Patagonia's testing with their worn wear products. For mending we assumed that the same leotard was used as before, that the information we found online is correct, and that the numbers reported by WRAP can be translated across markets to the U.S with reasonable certainty.

Total = 9.9×10^{-4} mPts/func unit

Input	mPts/func unit
Electricity, 120 V, US	9.33×10^{-4}
Nylon 66	2.08×10^{-5}
Tap water, at user	1.90×10^{-5}
Polyester fabric	1.19×10^{-5}
Textile refinement, cotton	4.42×10^{-6}
Injection molding, plastics	3.97×10^{-6}
Truck and trailer	1.02×10^{-6}
Truck and trailer	2.63×10^{-7}
Truck and trailer	1.82×10^{-7}
Tanker, oceanic	1.70×10^{-7}

Total = 5.6×10^{-4} mPts/func unit

Input	mPts/func unit
Electricity, 120 V, US	4.66×10^{-4}
Weaving, cotton	4.47×10^{-5}
Knit cotton fabric, dyed naturally	1.33×10^{-5}
Polyester fabric	1.19×10^{-5}
Tap water, at user	9.52×10^{-6}
Weaving, cotton	9.13×10^{-6}
Silicone product, components	9.24×10^{-7}
Truck and trailer	6.26×10^{-7}
Truck and trailer	2.63×10^{-7}
Truck and trailer	2.30×10^{-7}

Fig A.8 Cotton+ Green shield TRACI score

[25] http://www.wrap.org.uk/sites/files/wrap/valuing-our-clothes-the-cost-of-uk-fashion_WRAP.pdf

Total = 0.017 CO_2 eq. kg/func unit	
Input	CO_2 eq. kg/func unit
Electricity, 120 V, US	0.0158
Nylon 66	$3.92x10^{-4}$
Tap water, at user	$2.47x10^{-4}$
Polyester fabric	$2.28x10^{-4}$
Injection molding, plastics	$8.42x10^{-5}$
Textile refinement, cotton	$6.46x10^{-5}$
Truck and trailer	$1.38x10^{-5}$
Landfill, plastics, mixture	$4.51x10^{-6}$
Truck and trailer	$3.56x10^{-6}$
Truck and trailer	$2.46x10^{-6}$

Total = 0.0094 CO_2 eq. kg/func unit	
Input	CO_2 eq. kg/func unit
Electricity, 120 V, US	0.00789
Weaving, cotton	$7.84x10^{-4}$
Polyester fabric	$2.28x10^{-4}$
Weaving, cotton	$1.60x10^{-4}$
Knit cotton fabric, dyed naturally	$1.59x10^{-4}$
Tap water, at user	$1.24x10^{-4}$
Silicone product, components	$1.57x10^{-5}$
Truck and trailer	$8.47x10^{-6}$
Truck and trailer	$3.56x10^{-6}$
Truck and trailer	$3.12x10^{-6}$

Fig A.9 Cotton+ Green shield CO2 score

Name	Material/Process	Qty	Amt	Unit	mPts	CO_2 eq. kg	MS	F
— Tag		1	0.001	lb	$6.03x10^{-4}$	0.0108	E	
Material	Polyester fabric		0.001000(	lb	$4.39x10^{-4}$	0.00843	E	
Process	Textile refinement, cotton		0.001000(	lb	$1.64x10^{-4}$	0.00239	E	
— Spandex		1	0.1125	lb	0.0874	1.62	E	
Material	Polyester fabric		0.112499(	lb	0.0494	0.949	E	
Process	Weaving, cotton		0.112499(	lb	0.0380	0.667	E	
— Cotton		1	0.55	lb	0.241	3.92	E	
Material	Knit cotton fabric, dyed natu		0.550000(	lb	0.0553	0.659	E	
Process	Weaving, cotton		0.550000(	lb	0.186	3.26	E	
GreenShield finish	Silicone product, componen	1	0.05	lb	0.00384	0.0654	E	

Name	Consumables/water/power	Amt	Unit	mPts	CO_2 eq. kg	MS
— Power use				1.94	32.8	E
Power	Electricity, 120 V, US	39	kWh	1.94	32.8	E
— Water use				0.0396	0.514	E
Water	Tap water, at user	312	gal	0.0396	0.514	E
Consumables				0	0	
No consumables have been added to this SBOM.						

Name	End of life method	Qty	Amt	Unit	mPts	CO_2 eq. kg	MS
— Tag		1	0.001	lb	$1.28x10^{-6}$	$3.74x10^{-5}$	E
Material	Polyester fabric		0.0010000(	lb			E
Process	Landfill, polyethylene tereph		0.0010000(	lb	$1.28x10^{-6}$	$3.74x10^{-5}$	
— Spandex		1	0.1125	lb	$1.44x10^{-4}$	0.00421	E
Material	Polyester fabric		0.112499!	lb			E
Process	Landfill, polyethylene tereph		0.112499!	lb	$1.44x10^{-4}$	0.00421	
— Cotton		1	0.55	lb	$8.54x10^{-5}$	0.00138	E
Material	Knit cotton fabric, dyed natu		0.550000(	lb			E
Process	Landfill, sanitary, generic		0.550000(	lb	$8.54x10^{-5}$	0.00138	
— GreenShield finish		1	0.05	lb	$7.76x10^{-6}$	$1.26x10^{-4}$	E
Material	Silicone product, componen		0.050000(	lb			E
Process	Landfill, sanitary, generic		0.050000(	lb	$7.76x10^{-6}$	$1.26x10^{-4}$	
— Assembled product							
Factory to Hanover	Truck and trailer		200	mi	$9.59x10^{-4}$	0.0130	E
— Sub-assemblies and parts							
GreenShield finish	Silicone product, componen	1	0.05	lb			E
Tag	Polyester fabric	1	0.001	lb			E
— Spandex		1	0.1125	lb	0.00180	0.0233	E
Material	Polyester fabric		0.112499!	lb			E
Transportation	Tanker, oceanic		17000	mi	$7.05x10^{-4}$	0.00850	E
Distance from Indonesia where rubber is produced							
Transportation	Truck and trailer		1450	mi	0.00110	0.0148	E
Distance from Miami to Smithfield							
— Cotton		1	0.55	lb	0.00260	0.0352	E
Material	Knit cotton fabric, dyed natu		0.550000(	lb			E
Transportation	Truck and trailer		705	mi	0.00260	0.0352	E
Cotton fields in NC to manufacturing factory in Fall River, Massachusetts							

Fig. A.10 Cotton+ GreenShield fabric finish SBOM

Assumptions: Silicone components weighing 0.05lbs would be used to make GreenShield finish for each leotard. This assumption was made using information shared on GreenShield's website which said that silicone compounds make up major components used in GreenShield.

Total = 9.9×10^{-4} mPts/func unit	
Input	mPts/func unit
Electricity, 120 V, US	9.33×10^{-4}
Nylon 66	2.08×10^{-5}
Tap water, at user	1.90×10^{-5}
Polyester fabric	1.19×10^{-5}
Textile refinement, cotton	4.42×10^{-6}
Injection molding, plastics	3.97×10^{-6}
Truck and trailer	1.02×10^{-6}
Truck and trailer	2.63×10^{-7}
Truck and trailer	1.82×10^{-7}
Tanker, oceanic	1.70×10^{-7}

Total = 8.4×10^{-4} mPts/func unit	
Input	mPts/func unit
Cotton fibres	7.59×10^{-4}
Weaving, bast fibres	3.58×10^{-5}
Nylon 66	2.08×10^{-5}
Polyester fabric	1.19×10^{-5}
Truck and trailer	5.17×10^{-6}
Textile refinement, cotton	4.42×10^{-6}
Injection molding, plastics	3.97×10^{-6}
Landfill, sanitary, generic	4.94×10^{-7}
Sodium hydroxide, 50% in H2O, production mix	1.62×10^{-7}
Landfill, plastics, mixture	1.41×10^{-7}

Fig A.11 Wipes TRACI score

Total = 0.017 CO_2 eq. kg/func unit	
Input	CO_2 eq. kg/func unit
Electricity, 120 V, US	0.0158
Nylon 66	3.92×10^{-4}
Tap water, at user	2.47×10^{-4}
Polyester fabric	2.28×10^{-4}
Injection molding, plastics	8.42×10^{-5}
Textile refinement, cotton	6.46×10^{-5}
Truck and trailer	1.38×10^{-5}
Landfill, plastics, mixture	4.51×10^{-6}
Truck and trailer	3.56×10^{-6}
Truck and trailer	2.46×10^{-6}

Total = 0.0053 CO_2 eq. kg/func unit	
Input	CO_2 eq. kg/func unit
Cotton fibres	0.00360
Weaving, bast fibres	8.45×10^{-4}
Nylon 66	3.92×10^{-4}
Polyester fabric	2.28×10^{-4}
Injection molding, plastics	8.42×10^{-5}
Truck and trailer	6.99×10^{-5}
Textile refinement, cotton	6.46×10^{-5}
Landfill, sanitary, generic	7.98×10^{-6}
Landfill, plastics, mixture	4.51×10^{-6}
Polyester fabric	2.03×10^{-6}

Fig A.12 Wipes CO2 score

Name	Material/Process	Qty	Amt	Unit	mPts	CO_2 eq. kg	MS
Spandex		1	0.1125	lb	0.0678	1.22	E
Material	Polyester fabric		0.112499	lb	0.0494	0.949	E
Process	Textile refinement, cotton		0.112499	lb	0.0184	0.269	E
Nylon		1	0.449999	lb	0.103	1.98	E
Material	Nylon 66		0.449999	lb	0.0867	1.63	E
Process	Injection molding, plastics		0.449999	lb	0.0165	0.350	E
Tag		1	0.001	lb	$6.03x10^{-4}$	0.0108	E
Material	Polyester fabric		0.001000	lb	$4.39x10^{-4}$	0.00843	E
Process	Textile refinement, cotton		0.001000	lb	$1.64x10^{-4}$	0.00239	E
Wipes		400	15	g	3.31	18.5	E
Material	Cotton fibres		15	g	0.00790	0.0375	E
Process	Weaving, bast fibres		15	g	$3.72x10^{-4}$	0.00878	E
Detergent	Sodium hydroxide, 50% in H	1	5	g	$6.73x10^{-4}$	0.00797	E
Part	Demineralized water	20	50	g	$8.64x10^{-5}$	0.00103	E

Name	Consumables/water/power	Amt	Unit	mPts	CO_2 eq. kg	MS
Power use				0	0	
No power use has been added to this SBOM.						
Water use				0	0	E
No water use has been added to this SBOM.						
Consumables				0	0	
No consumables have been added to this SBOM.						

Name	End of life method	Qty	Amt	Unit	mPts	CO_2 eq. kg	MS
— Spandex		1	0.1125	lb	1.44×10^{-4}	0.00421	E
Material	Polyester fabric		0.112499	lb			E
Process	Landfill, polyethylene tereph		0.112499	lb	1.44×10^{-4}	0.00421	
— Nylon		1	0.449999	lb	5.85×10^{-4}	0.0188	E
Material	Nylon 66		0.449999	lb			E
Process	Landfill, plastics, mixture		0.449999	lb	5.85×10^{-4}	0.0188	
— Tag		1	0.001	lb	1.28×10^{-6}	3.74×10^{-5}	E
Material	Polyester fabric		0.001000	lb			E
Process	Landfill, polyethylene tereph		0.001000	lb	1.28×10^{-6}	3.74×10^{-5}	
— Detergent		1	5	g	1.71×10^{-6}	2.77×10^{-5}	E
Material	Sodium hydroxide, 50% in H		5	g			E
Process	Landfill, sanitary, generic		5	g	1.71×10^{-6}	2.77×10^{-5}	
— Wipes		400	15	g	0.00205	0.0332	E
Material	Cotton fibres		15	g			E
Process	Landfill, sanitary, generic		15	g	5.13×10^{-6}	8.30×10^{-5}	
Part	Demineralized water	20	50	g			E

Assembled product							
Factory to Hanover	Truck and trailer		200	mi	0.0215	0.291	E
Sub-assemblies and parts							
Detergent	Sodium hydroxide, 50% in H	1	5	g	7.54×10^{-5}	0.00116	E
Material	Sodium hydroxide, 50% in H		5	g			E
Transportation	Truck, 3.5-7.5t		200	mi	7.54×10^{-5}	0.00116	E
Part	Demineralized water	20	50	g	0.0151	0.231	E
Material	Demineralized water		50	g			E
Transportation	Truck, 3.5-7.5t		200	mi	7.54×10^{-4}	0.0116	E
Spandex		1	0.1125	lb	0.00180	0.0233	E
Material	Polyester fabric		0.112499	lb			E
Transportation	Tanker, oceanic		17000	mi	7.05×10^{-4}	0.00850	E
Distance from Indonesia where rubber is produced							
Transportation	Truck and trailer		1450	mi	0.00110	0.0148	E
Distance from Miami to Smithfield							
Nylon		1	0.449999	lb	0.00423	0.0572	E
Material	Nylon 66		0.449999	lb			E
Transportation	Truck and trailer		1400	mi	0.00423	0.0572	E
Tag		1	0.001	lb	1.34×10^{-6}	1.82×10^{-5}	E
Material	Polyester fabric		0.001000	lb			E
Transportation	Truck and trailer		200	mi	1.34×10^{-6}	1.82×10^{-5}	E
Wipes		400	15	g	0.0178	0.240	E
Material	Cotton fibres		15	g			E
Transportation	Truck and trailer		200	mi	4.44×10^{-5}	6.01×10^{-4}	E

Fig. A.13 - Cleansing wipes SBOM

Following assumptions were made for LCA of Cleansing wipes:

1. Demineralized water was used as a proxy for solvents
2. Sodium hydroxide was used as a proxy for sodium salts used in detergents
3. 50% concentration of sodium hydroxide was used
4. Cotton wipes weighing 15g each were used
5. Weaving, bast fibres technique for manufacturing cotton fibres was used as cleansing wipes need not be ultra soft
6. Transportation distance were assumed to be 200 miles for demineralized water, wipes and detergent

Total = 9.9×10^{-4} mPts/func unit

Input	mPts/func unit
Electricity, 120 V, US	9.33x10-4
Nylon 66	2.08x10-5
Tap water, at user	1.90x10-5
Polyester fabric	1.19x10-5
Textile refinement, cotton	4.42x10-6
Injection molding, plastics	3.97x10-6
Truck and trailer	1.02x10-6
Truck and trailer	2.63x10-7
Truck and trailer	1.82x10-7
Tanker, oceanic	1.70x10-7

Total = 5.0×10^{-4} mPts/func unit

Input	mPts/func unit
Electricity, 120 V, US	4.66x10-4
PET fibers, recycled granulate	2.20x10-5
Tap water, at user	9.36x10-6
Silver, secondary, at precious metal refinery	7.52x10-7
Truck and trailer	6.47x10-7
Truck and trailer	1.86x10-7
Polyester fabric	1.06x10-7
Textile refinement, cotton	3.93x10-8
Landfill, polyethylene terephtalate	3.07x10-10
Saw cutting, metal	1.37x10-10

Fig A.14 REPREVE + Antimicrobial TRACI score

Total = 0.017 CO_2 eq. kg/func unit

Input	CO_2 eq. kg/func unit
Electricity, 120 V, US	0.0158
Nylon 66	3.92x10-4
Tap water, at user	2.47x10-4
Polyester fabric	2.28x10-4
Injection molding, plastics	8.42x10-5
Textile refinement, cotton	6.46x10-5
Truck and trailer	1.38x10-5
Landfill, plastics, mixture	4.51x10-6
Truck and trailer	3.56x10-6
Truck and trailer	2.46x10-6

Total = 0.0086 CO_2 eq. kg/func unit

Input	CO_2 eq. kg/func unit
Electricity, 120 V, US	0.00789
PET fibers, recycled granulate	5.04x10-4
Tap water, at user	1.22x10-4
Silver, secondary, at precious metal refinery	1.93x10-5
Truck and trailer	8.75x10-6
Truck and trailer	2.51x10-6
Polyester fabric	2.03x10-6
Textile refinement, cotton	5.74x10-7
Landfill, polyethylene terephtalate	8.99x10-9
Saw cutting, metal	3.27x10-9

Fig A.15 REPREVE + Antimicrobial CO2 score

Name	Material/Process	Qty	Amt	Unit	mPts	CO_2 eq. kg	MS	Part ID
Polygiene Treatme		1	0.011	lb	0.00313	0.0803	E	
Polygiene treatment is applied at the finishing stages of textile. It uses low concentrations of silver chloride, which has antimicrobial properties. Assume silver is a substitute for silver chloride. Also assume you only coat the inner layer of the leotard and that the amount of the coating is 1/50th that of the fabric. Link: https://polygiene.com/how-it-works/								
Material	Silver, secondary, at preciou		0.010999!	lb	0.00313	0.0803	E	
Process	Saw cutting, metal		0.010999!	lb	$5.68x10^{-7}$	$1.36x10^{-5}$	E	
Tag		1	0.001	lb	$6.03x10^{-4}$	0.0108	E	
A piece of paper weighs 0.01 lbs, so the tag likely doesn't weigh more than 0.001 lbs.								
Material	Polyester fabric		0.001000(	lb	$4.39x10^{-4}$	0.00843	E	
Process	Textile refinement, cotton		0.001000(	lb	$1.64x10^{-4}$	0.00239	E	
REPREVE	PET fibers, recycled granula	1	0.5625	lb	0.0915	2.10	E	
	Manufacturing total				**0.0952**	**2.19**	**E**	

Name	Consumables/water/power	Amt	Unit	mPts	CO_2 eq. kg	MS
Consumables				0	0	
No consumables have been added to this SBOM.						
Water use				0.0390	0.506	E
Water	Tap water, at user	307	gal	0.0390	0.506	E
Assume the leotard is always washed with 20 other similar garments (12480 gal/20 = 624 gal). Assume that antimicrobial treatment allows you to wash the leotard 50% less (307 gal)						
Power use				1.94	32.8	E
Power	Electricity, 120 V, US	39	kWh	1.94	32.8	E
Assume you wash the leotard with 20 other similar garments (1560/20=78kWh). Assume antimicrobial fabric allows you to wash the leotard 50% of the time (39kWh).						
	Use total			**1.98**	**33.3**	**E**

Name	End of life method	Qty	Amt	Unit	mPts	CO_2 eq. kg	MS	Part ID
Polygiene Treatme		1	0.011	lb	0	0	E	
Polygiene treatment is applied at the finishing stages of textile. It uses low concentrations of silver chloride, which has antimicrobial properties. Assume silver is a substitute for silver chloride. Also assume you only coat the inner layer of the leotard and that the amount of the coating is 1/50th that of the fabric. Link: https://polygiene.com/how-it-works/								
Material	Silver, secondary, at preciou		0.010999!	lb			E	
Process	Recycling		0.010999!	lb	0	0		
Tag		1	0.001	lb	$1.28x10^{-6}$	$3.74x10^{-5}$	E	
A piece of paper weighs 0.01 lbs, so the tag likely doesn't weigh more than 0.001 lbs.								
Material	Polyester fabric		0.001000(	lb			E	
Process	Landfill, polyethylene tereph		0.001000(	lb	$1.28x10^{-6}$	$3.74x10^{-5}$		
REPREVE		1	0.5625	lb	0	0	E	
Material	PET fibers, recycled granula		0.5625	lb			E	
Process	Recycling		0.5625	lb	0	0		
	End of Life total				**$1.28x10^{-6}$**	**$3.74x10^{-5}$**	**E**	

Name	Transportation mode	Qty	Amt	Unit	mPts	CO_2 eq. kg	MS	Part ID	
— Assembled product									Add trans. mode +
Factory to Hanover	Truck and trailer		200	mi	7.72x10-4	0.0104	E		
Distance from factory in Smithfield, RI to Hanover, NH.									
— Sub-assemblies and parts									
— REPREVE	PET fibers, recycled granula	1	0.5625	lb	0.00269	0.0364	E		Add trans. mode +
Material	PET fibers, recycled granula		0.5625	lb			E		
Transportation	Truck and trailer		712	mi	0.00269	0.0364	E		
Distance from REPREVE manufacturing plant in Greensboro, NC to leotard manufacturing factory in Smithfield, RI.									
— Polygiene Treatment		1	0.011	lb	0	0	E		Add trans. mode +
Polygiene treatment is applied at the finishing stages of textile. It uses low concentrations of silver chloride, which has antimicrobial properties. Assume silver is a substitute for silver chloride. Also assume you only coat the inner layer of the leotard and that the amount of the coating is 1/50th that of the fabric. Link: https://polygiene.com/how-it-works/									
Material	Silver, secondary, at preciou		0.010999	lb			E		
Transportation	Truck and trailer		0	mi	0	0	E		
Assume the Polygiene treatment is applied at the factory in Smithfield, RI.									
Tag	Polyester fabric	1	0.001	lb			E		Add trans. mode +
A piece of paper weighs 0.01 lbs, so the tag likely doesn't weigh more than 0.001 lbs.									
	Transportation total				**0.00346**	**0.0468**	**E**		

Fig A.16 REPREVE + Antimicrobial SBOM

Assumptions: Silver was used as a proxy for silver chloride in the Polygiene treatment because silver chloride is not in the Sustainable Minds database. Also, Polygiene has been shown to reduce washing by 50-75%, so for this analysis, we used the conservative estimate that Polygiene would lead to a 50% reduction in washing (50% of electricity and water consumed compared to the baseline). Assumptions regarding transportation are outlined in the figure.

Total = $9.9x10^{-4}$ mPts/func unit

Input	mPts/func unit
Electricity, 120 V, US	9.33x10-4
Nylon 66	2.08x10-5
Tap water, at user	1.90x10-5
Polyester fabric	1.19x10-5
Textile refinement, cotton	4.42x10-6
Injection molding, plastics	3.97x10-6
Truck and trailer	1.02x10-6
Truck and trailer	2.63x10-7
Truck and trailer	1.82x10-7
Tanker, oceanic	1.70x10-7

Total = $4.3x10^{-4}$ mPts/func unit

Input	mPts/func unit
Electricity, 120 V, US	3.80x10-4
Nylon 66	2.08x10-5
Polyester fabric	1.19x10-5
Tap water, at user	4.92x10-6
Textile refinement, cotton	4.42x10-6
Injection molding, plastics	3.97x10-6
Truck and trailer	1.02x10-6
Truck and trailer	2.63x10-7
Truck and trailer	1.82x10-7
Tanker, oceanic	1.70x10-7

Fig A.17 Salad Spinner Washing TRACI points

Total = 0.017 CO_2 eq. kg/func unit

Input	CO_2 eq. kg/func unit
Electricity, 120 V, US	0.0158
Nylon 66	3.92x10-4
Tap water, at user	2.47x10-4
Polyester fabric	2.28x10-4
Injection molding, plastics	8.42x10-5
Textile refinement, cotton	6.46x10-5
Truck and trailer	1.38x10-5
Landfill, plastics, mixture	4.51x10-6
Truck and trailer	3.56x10-6
Truck and trailer	2.46x10-6

Total = 0.0073 CO_2 eq. kg/func unit

Input	CO_2 eq. kg/func unit
Electricity, 120 V, US	0.00643
Nylon 66	3.92x10-4
Polyester fabric	2.28x10-4
Injection molding, plastics	8.42x10-5
Textile refinement, cotton	6.46x10-5
Tap water, at user	6.38x10-5
Truck and trailer	1.38x10-5
Landfill, plastics, mixture	4.51x10-6
Truck and trailer	3.56x10-6
Truck and trailer	2.46x10-6

Fig A.18 Salad Spinner Washing Carbon Footprint

Name	Consumables/water/power	Amt	Unit	mPts	CO_2 eq. kg	MS	
Power use				1.58	26.7	E	Add Power Use +
Power	Electricity, 120 V, US	31.7699	kWh	1.58	26.7	E	
Energy use in washing once per week, every week, for four years, divided by 20 as to account for the impact of the other clothing							
Consumables				0	0		Add Consumables +
No consumables have been added to this SBOM.							
Water use				0.0205	0.266	E	Add Water Use +
Water	Tap water, at user	161.2	gal	0.0205	0.266	E	
Washing once a week, every week, for four years (this amount of water then divided by 20 to account for the impact of the other clothing in the washer)							
	Use total			**1.60**	**27.0**	**E**	

Fig A.19 Salad Spinner SBOM Differences in Use Phase

For the salad spinner washing solution, the only changed/impacted category is the use phase; every other part of the SBOM study remains the same. The above figure depicts the decrease in the amount of power and water use with the salad spinner solution. There is a decrease in power and water use because the only electricity needed is to heat the water to wash the leotard, and there is less water used per leotard than with a typical washing machine.

Assumptions made: For the salad spinning washing method, we assumed that consumers would only wash their leotards with salad spinners per our instruction. However, we are fundamentally unable to control customer behavior, and it is very possible that dancers would use their washing machines for their leotards out of convenience. We also assumed that every dancer would have a salad spinner, which presents a barrier to entry to using Corleone leotards sustainably.

Total = $9.9x10^{-4}$ mPts/func unit

Input	mPts/func unit
Electricity, 120 V, US	9.33x10-4
Nylon 66	2.08x10-5
Tap water, at user	1.90x10-5
Polyester fabric	1.19x10-5
Textile refinement, cotton	4.42x10-6
Injection molding, plastics	3.97x10-6
Truck and trailer	1.02x10-6
Truck and trailer	2.63x10-7
Truck and trailer	1.82x10-7
Tanker, oceanic	1.70x10-7

Total = $1.0x10^{-4}$ mPts/func unit

Input	mPts/func unit
Electricity, 120 V, US	3.74x10-5
Nylon 66	2.08x10-5
Tap water, at user	1.90x10-5
Polyester fabric	1.19x10-5
Textile refinement, cotton	4.42x10-6
Injection molding, plastics	3.97x10-6
Truck and trailer	1.02x10-6
Truck and trailer	2.63x10-7
Truck and trailer	1.82x10-7
Tanker, oceanic	1.70x10-7

Fig A.20 Dance Floor TRACI score

Total = $9.9x10^{-4}$ mPts/func unit

Input	mPts/func unit
Electricity, 120 V, US	9.33x10-4
Nylon 66	2.08x10-5
Tap water, at user	1.90x10-5
Polyester fabric	1.19x10-5
Textile refinement, cotton	4.42x10-6
Injection molding, plastics	3.97x10-6
Truck and trailer	1.02x10-6
Truck and trailer	2.63x10-7
Truck and trailer	1.82x10-7
Tanker, oceanic	1.70x10-7

Total = $1.0x10^{-4}$ mPts/func unit

Input	mPts/func unit
Electricity, 120 V, US	3.74x10-5
Nylon 66	2.08x10-5
Tap water, at user	1.90x10-5
Polyester fabric	1.19x10-5
Textile refinement, cotton	4.42x10-6
Injection molding, plastics	3.97x10-6
Truck and trailer	1.02x10-6
Truck and trailer	2.63x10-7
Truck and trailer	1.82x10-7
Tanker, oceanic	1.70x10-7

Fig A.21 Dance Floor CO2 score

Name	Consumables/water/power	Amt	Unit	mPts	CO_2 eq. kg	MS	
Water use				0.0792	1.03	E	Add Water Use +
Water	Tap water, at user	624	gal	0.0792	1.03	E	
Washing once a week, every week, for four years (this amount of water then divided by 20 to account for the impact of the other clothing in the washer)							
Power use				0.156	2.63	E	Add Power Use +
Power	Electricity, 120 V, US	3.128	kWh	0.156	2.63	E	
Energy use in washing once per week, every week, for four years, divided by 20 as to account for the impact of the other clothing							
Consumables				0	0		Add Consumables +
No consumables have been added to this SBOM.							
	Use total			0.235	3.66	E	

Fig A.22 Dance Floor SBOM Differences in Use Phase

For the Energy Floors solution, the use phase was the only impacted phase of the SBOM. Here, the energy generated from the dance floors would be put directly towards the energy used in washing the leotards (at the dance studio). Because all the leotards would be washed at the dance studio (and only leotards/other dance clothing would be going into each load), we also assumed that the dance studios would wash the leotards on cold/cold, further reducing the impact from the use phase.

Assumptions made: For the dance floor, we made a lot of assumptions. The LCA was calculated without the inclusion of the dance floor's material impact, or EOL potential. This was mainly due to our confusion surrounding the materials used in the dancefloor and its life cycle. Additionally, the impacts associated with the entire dance floor are difficult to extrapolate to hours of use by one leotard. The dance floor idea is exciting and interesting, but overall hard to tell how sustainable it really is.

- We assumed that all of the power generated for the dance floor could be used to then power the washing machines in the dance studio, and that the dance studios themselves would have washing machines (so that we could be certain that they were washing their leotards on cold/cold).
- We assumed that dance studios would be able and willing to install the energy floors, and that they would perform as well as normal dance studio floors (so that dance studios would want to use them).

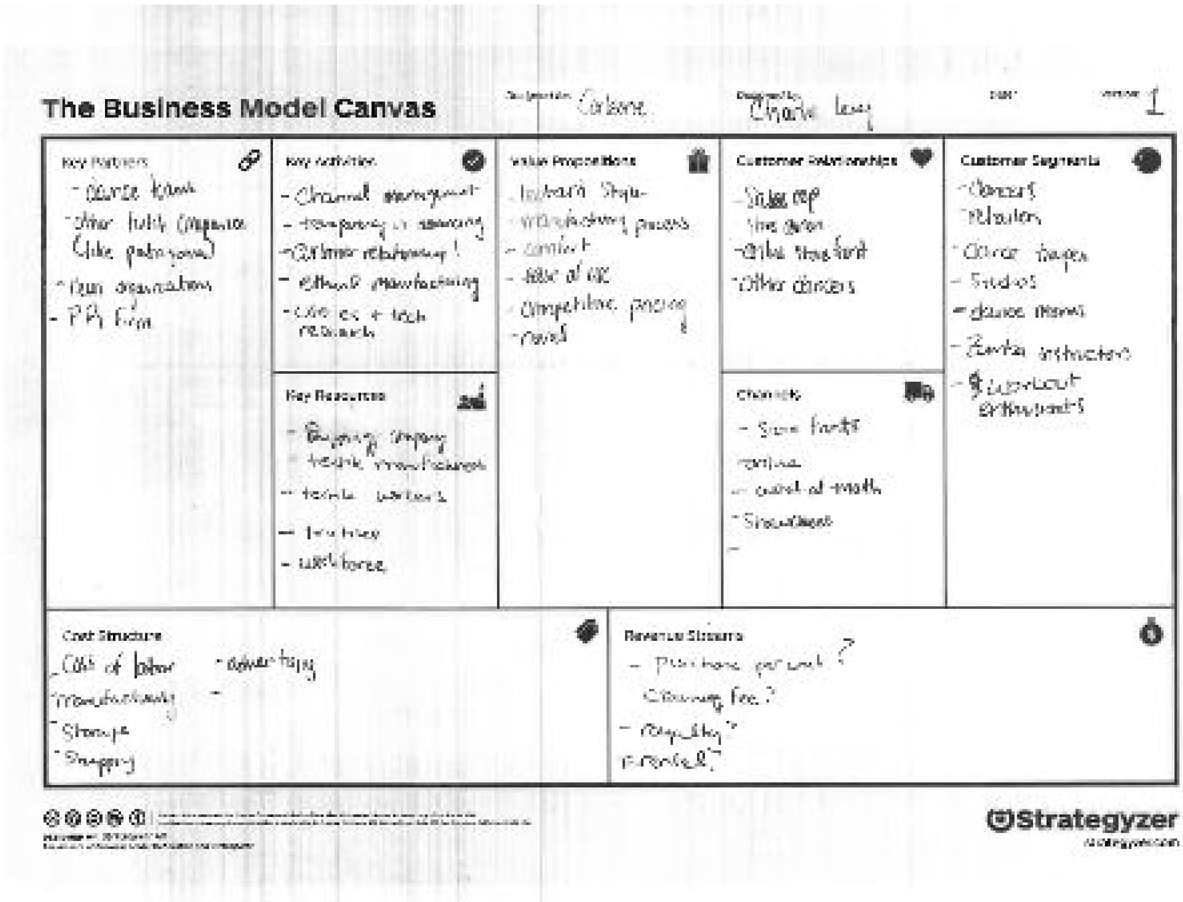

Fig A.23 - Business Model Canvas

Criteria	Required? Basic	Bronze	Silver	Gold	Platinum	Pessimistic Score (Yes = 1, No = 0)	Optimistic Score (Yes = 1, No = 0)
						Red bold answers are uncertain.	
1.0 Materials							
All material ing	x	x	x	x	x	0	0
All material ing	x	x	x	x	x	**1**	**1**
Does not conta	x	x	x	x	x	**0**	**1**
Materials assessed for their intended use and impact on Human/Environmental Health according tothe following criteria: - Human Health: Carcinogenicity, Endocrine Disruption, Mutagenicity, Reproductive Toxicity, Teratogenicity, Acute Toxicity, Chronic Toxicity, Irritation, Sensitization							
≥ 75% (by weight) of ingredients a		x	x	x	x	**1**	1
≥ 95% (by weight) of ingredients assessed (Or, for e			x	x	x	**0**	1
100% (by weight) of ingredients assessed, and none have "X" assess				x	x	**0**	1
Meets Cradle to Cradle emission standards				x	x	0	1
All process chemicals also assessed, and none have "X" assessment					x	0	1
2.0 Material Reutilization/Design for Environment							
Material Reutilization Score ≥		x	x	x	x	0	**1**
Material Reutilization Score ≥ 50			x	x	x	0	**1**
Material Reutilization Score ≥ 65				x	x	0	**1**
Material Reutilization Score = 100					x	0	**1**
Have "nutrient management" strategy for the product includi				x		0	**1**
Product is actively being recovered and cycled in a technical or biological me					x	0	**1**
3.0 Energy							
Quantified ene	x	x	x	x	x	0	1
Developed strategy for using r		x	x	x	x	1	1
≥ 5% of electricity for final mfg stage is renev ≥ 5% of direct on-site emissions are offset			x	x	x	0	0
≥ 50% of electricity for final mfg stage is renewaby sourced (≥ 50% of direct on-site emissions are offset				x	x	0	0
> 100% of electricity for final mfg stage is renewaby sourced or offset with F > 100% of direct on-site emissions are offset					x	0	0
Embodied energy is quantified (amount & sources), and strategy developed					x	**0**	**1**
≥ 5% of embodied energy covered by offsets or otherwise addressed					x	0	0
4.0 Water							
Created or ado	x	x	x	x	x	0	1
Haven't violate	x	x	x	x	x	1	1
Determined if \	x	x	x	x	x	0	1
Facility-wide water audit		x	x	x	x	**0**	**1**
Assessed all process chemicals in effluent OR Characterized ≥ 20% of Tier 1 suppliers' che			x	x	x	0	0
No problematic process chemicals in effluent (either removed OR Demonstrated progress on Tier 1 suppliers strategy from "Si				x	x	0	1
All water leaving manufacturing facility meets drinking water quality standar					x	0	1
5.0 Social Responsibility							
Streamlined se	x	x	x	x	x	0	1
Management p	x	x	x	x	x	0	1
Full social responsibility self-a		x	x	x	x	0	1
Performed material-specific and/or issue-relat OR Supply chain social issues are fully investigat OR Company is actively conducting an innovative			x	x	x	0	1
2 of the 3 "Silver" requirements done				x	x	0	**1**
All 3 "Silver" requirements done					x	0	**1**
Acceptable third party social responsibility assessment, accreditation, or cert					x	0	**1**

Pessimistic Total Score	Optimistic Total Score
4	29

Fig A.24 Cradle to Cradle Certification

We updated our optimistic score to reflect our winning finalist idea (REPREVE + Antimicrobial treatment (Polygiene). The score for this solution is now 29, which is only 6 off from achieving the C2C bronze certification! There is still some uncertainty in both columns, but as transparency is one of Corleone's main focuses (and REPREVE's and Polygiene - Patagonia antimicrobial), we believe that Corleone's manufacturing will meet more of the C2C requirements.

Overview of Cradle-to-Cradle Certification Assumption

Best-case scenario: 29
Worst-case scenario: 5

In neither of these cases does our product achieve a certification through the Cradle to Cradle Certification process. The upside of this is that with Corleone, we have only the possibility of being better if we are able to meet a certification standard. In doing this exercise, we realized how important water management is, specifically in textile refinement. This was not clear in the Sustainable Minds LCA analysis, and the act of answering specific questions drew our attention to areas that we really want to focus on in our solution: like the end of life potential (having a strict plan for how to go about material reutilization) and in the importance in knowing where our materials are coming from, and making sure that they are the most sustainable they can be. It is also important to note that the worst-case scenario for textiles is shockingly low, and that in focusing a company on sustainable principals there may be a lot of work on our side in trying to meet more of these criteria.

Cradle to Cradle Explanation and Assumptions

In going through the template to determine our score, we made the following assumptions. To make this clearer (and not in the form of an extended excel document), we have put the criteria for certification with the explanation of our research and areas of uncertainty.

Materials:
All material ingredients identified (down to the 100 ppm level): Textiles are very complex, as the materials come from many different areas. Therefore, with our limited knowledge we don't feel confident saying we know what makes up the entirety of piece of clothing down to 100 ppm.

All material ingredients defined as biological nutrient (BN) or technical nutrient (TN): We think this is most likely yes, because all materials are plastic or metal.

Does not contain any Banned List substances: The product ideally would not contain any banned substances. However there are cases of leotards containing halogens and other substances that are listed on the banned substances list.

”Materials assessed for their intended use and impact on Human/Environmental Health according to the following criteria:

≥ 75% (by weight) of ingredients assessed, and any scoring "X" in assessment have strategy to phase them out: Because of more stringent requirements for textiles, we believe that these the textiles used in dance leotards (and specifically in Corleone's leotards) will meet these standards.

≥ 95% (by weight) of ingredients assessed (Or, for entirely BN products, 100%), and none have "X" assessment: Though we don't believe that the typical dance leotard has assessed the full human/environmental health impacts, we are fairly confident that Corleone's leotards will be able to achieve this standard.

100% (by weight) of ingredients assessed, and none have "X" assessment: Though we don't believe that the typical dance leotard has assessed the full human/environmental health impacts, we are fairly confident that Corleone's leotards will be able to achieve this standard.

Meets Cradle to Cradle emission standards: The company would ideally test using one of the methods listed on the Cradle to Cradle Assessment. However, there are very few sustainability reports from companies in the dance wear industry, which leads us to believe sustainability is not a priority for most.

All process chemicals also assessed, and none have "X" assessment: Though we don't believe that the typical dance leotard has assessed the full human/environmental health impacts, we are fairly confident that Corleone's leotards will be able to achieve this standard.

Material Reutilization/Design for the Environment

Material Reutilization Score ≥ 35: Currently all goes to landfill without much evidence to suggest that any of it is reutilized. One of Corleone's main tenets, however, is to try to have an EOL solution for their leotards, so we believe that there will be a plan in place for material reutilization.

Material Reutilization Score ≥ 50: Currently all goes to landfill without much evidence to suggest that any of it is reutilized. One of Corleone's main tenets, however, is to try to have an EOL solution for their leotards, so we believe that there will be a plan in place for material reutilization.

Material Reutilization Score ≥ 65: Currently all goes to landfill without much evidence to suggest that any of it is reutilized. One of Corleone's main tenets, however, is to try to have an EOL solution for their leotards, so we believe that there will be a plan in place for material reutilization.

Material Reutilization Score = 100: Currently all goes to landfill without much evidence to suggest that any of it is reutilized. One of Corleone's main tenets, however, is to try to have an EOL solution for their leotards, so we believe that there will be a plan in place for material reutilization.

Have "nutrient management" strategy for the product including scope, timeline, and budget: The lack of sustainability reports leads us to believe that there is not a focus on recycling nutrients. Considering the amount of non-recyclable materials in most common leotards, we assume that the industry is not focused on this type of cycle. Again, Corleone has expressed interest and dedication to changing this, so we believe that this could be a viable part of Corleone's business model.

Product is actively being recovered and cycled in a technical or biological metabolism: Industry standards point to cradle-to-grave practices. Most of the chemicals used are dyes and solvents which become a part of the clothing or need to be disposed of. Again, Corleone has expressed interest and dedication to changing this, so we believe that this could be a viable part of Corleone's business model.

Energy:

Quantified energy use and source(s) for final stage of product manufacture/assembly: Found in some cases, though companies and factories seem to have vastly different levels of information on this topic.

Developed strategy for using renewable energy & managing carbon: Did not find a case of this being developed. However, we believe that Corleone could push for this in the factories/processing plants they use.

"≥ 5% of electricity for final mfg stage is renewably sourced or offset with Renewable Energy Credits, and ≥ 5% of direct on-site emissions are offset": Company buys normal grid power.

"≥ 50% of electricity for final mfg stage is renewably sourced or offset with Renewable Energy Credits, and ≥ 50% of direct on-site emissions are offset": Company buys normal grid power.

"> 100% of electricity for final mfg stage is renewably sourced or offset with Renewable Energy Credits, and > 100% of direct on-site emissions are offset": Company buys normal grid power.

Embodied energy is quantified (amount & sources), and strategy developed to optimize: Did not find evidence of this in company/factory reports. With some degree of uncertainty, we believe that Corleone could achieve this in part of their analysis in being transparent with customers.

≥ 5% of embodied energy covered by offsets or otherwise addressed: Did not find evidence of this in company/factory reports.

Water:
Created or adopted water stewardship principles/guidelines: Yes, in compliance with US regulations surrounding water. Even though the Clean Water Act wasn't renewed, we believe that Corleone will put emphasis on water stewardship for the factories that it outsources to.

Haven't violated discharge permit in last 2 years: Didn't find anything to suggest that a permit and been violated.

Determined if water scarcity or sensitive ecosystems are issues around their factories: Unsure because water law is strict in the US, but to determine the threat to aquatic ecosystems in the area seems like too far of a stretch for some of these companies (especially given there is no data on this online). Again, we do believe that this is something that Corleone would focus on, especially in terms of their accountability to their customers.

Facility-wide water audit: Unsure because though factories are conscientious of the water they put out (required by law) a full water audit seems like an extra step that only some facilities are doing as to appeal to a more sustainable consumer base. Since we have seen little of this rhetoric in current dance production, I would pessimistically guess that this is not done at most factories.

"Assessed all process chemicals in effluent OR Characterized ≥ 20% of Tier 1 suppliers' chemical effluent and water depletion. Strategy developed to optimize": Due to the toxic nature of making polyester, this seems like a hard one for the baseline to hit, even optimistically. The chemicals used in textile refinement do not currently comply with a lot of the Cradle to Cradle standards for certification.

"No problematic process chemicals in effluent (either removed from process or recycled to not enter effluent) OR Demonstrated progress on Tier 1 suppliers strategy from ""Silver"" level": The use of toxic chemicals in fashion is widely documented, unfortunately not all industry leaders stick to regulations such

as REACH. We do believe that Corleone could achieve this standard by advocating to the factories that they use.

All water leaving manufacturing facility meets drinking water quality standards: The production of spandex and nylon requires toxic chemicals that mix with water. Ideally this water would be treated, but realistically this is not likely to happen to a drinking level safe amount. e do believe that Corleone could achieve this standard by advocating to the factories that they use.

Social Responsibility:
Streamlined self-audit performed to assess protection of fundamental human rights: Often the garment industry has cases of workers rights abuses. While in recent years this has improved, the worst case scenario would point to there being an oversight of workers rights. We believe that, again, this would be a focus of Corleone Dancewear.

Management procedures developed to fix any problems found in self-audit: Though not fully fleshed out in the companies that we looked at, Corleone seems to have the desire and the drive to fix problems found in self-audit, especially as they want to remain transparent, and thus accountable to their consumers.

Full social responsibility self-audit performed & positive-impact strategy developed: Though not fully fleshed out in the companies that we looked at, Corleone seems to have the desire and the drive to fix problems found in self-audit, especially as they want to remain transparent, and thus accountable to their consumers.

"Performed material-specific and/or issue-related audit relevant to ≥ 25% of product material (by weight), e.g. FSC Certified, Fair Trade, etc. OR Supply chain social issues are fully investigated & positive-impact strategy developed. ORCompany is actively conducting an innovative social project that positively impacts employee's lives, the local community, global community, social aspects of supply chain, or recycling/reuse.": Corleone has expressed interest in only using Fair Trade certified textiles, examining their entire supply chain, and trying to include a side of their business that would give back to the community (dance studio donations, underprivileged dance classes, etc).

2 of the 3 "Silver" requirements done: For leotards, material health would be of prime importance because of the user's high level of exposure to the product. Hence, it is reasonable to assume that any respectable producer of dance leotards would have performed material inspection. However, the other two factors are like material recyclability and renewable energy consumption would be difficult to achieve. Corleone has expressed interest in only using Fair Trade certified textiles, examining their entire supply chain, and trying to include a side of their business that would give back to the community (dance studio donations, underprivileged dance classes, etc).

All 3 "Silver" requirements done: The reutilization of nylon is not very common. For most leotards, we cannot ensure that renewable energy is used along all steps in the manufacturing line. Corleone has expressed interest in only using Fair Trade certified textiles, examining their entire supply chain, and trying to include a side of their business that would give back to the community (dance studio donations, underprivileged dance classes, etc).

Acceptable third party social responsibility assessment, accreditation, or certification: The production of spandex involves farmers in rubber plantations in different countries. The variation in labour laws are a hurdle to uniform practices and hence complete transparency with third party partners is not possible.

Corleone has expressed interest in only using Fair Trade certified textiles, examining their entire supply chain, and trying to include a side of their business that would give back to the community (dance studio donations, underprivileged dance classes, etc).