Sheffield Hallam University | Centre for Sports Engineering Research

BIKE BUDDIES CHILD BIKE HELMET

PRODUCT SUMMARY

SHEFFIELD HALLAM UNIVERSITY | MSC SPORTS ENGINEERING\ DESIGN & INNOVATION

A COMPILATION OF RESEARCH WORK AND PRODUCT DEVELOPMENT SUMMARY. FOLLOWED BY AN INDEPTH BUSINESS CASE SUMMARY.

EXCECUTIVE SUMMARY

This project was formed to satisfy the completion of MSc coursework for the Design & Innovation module (2019-2020). Motivated by the popularity of cycling at a youth level, and the inherent need for personal safety equipment. The project pursues the development of a novel helmet for sports such as recreational cycling. The following report will outline the consumer centred design process from ideation to industry implementation.

ABOUT THE TEAM





With a combined 25 years of hybrid product innovation experience, the international Bike Bud team hails from the USA, India, and England. Primary fields include: sports science, sport management, materials science, sports technology, and global sourcing. The team is motivated to provide a thorough and thoughtful product offering.

The team would like to thank the educational staff in guiding the project. Special thanks to Nick Hamilton and John Hart for their mentorship.

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1. Introduction

The design brief raised the challenge to design a novel cycling helmet using a human centered design (HCD) approach. HCD is a concept based on designing a good or service with an emphasis placed on understanding the user's wants, needs and preferences. The design is optimized by a subjective analysis by the designer based on what they think the users want, and what is technologically possible (Giacomin, 2014; Steen, 2011). An iterative design process was followed with each new design iteration being led by feedback on the preceding iteration and how to better meet user needs.

Initial inspiration for framing the design challenge came from challenging the assumption that everyone learned to ride a bike as a child. This led to initial questions such as:

- Where/When/Why/How did you learn to ride a bike?
- What was in place to allow this?
- Who helped you?
- Why someone may or may not learn to ride a bike?
- What prevented them? Can this be mitigated in any way?
- What could help more people learn to ride a bike as a child?
- How can this be done?

Key themes such as safety, time, cost and accessibility were drawn from these questions. Based on a frequency analysis it became apparent that addressing safety concerns was the main issue that should be addressed when creating an effective helmet design.

This led to the following revised design challenge that was referenced throughout the full design process.

"Design a helmet which can help facilitate a safer, more inclusive and fun learning experience for children learning to ride a bike"

The following sections will inform the reader on the process, validation, and proposed businesses model to bring the aforementioned product to market.

2. Understanding the Problem

2.1. Literature

The literature sources found helmet ownership was associated with higher parental education. Conversely, this did not have a strong correlation to users actually wearing helmets (DiGuiseppi et al, 1990). Reasons for not wearing the helmet was determined to stem from social desirability and comfort limitations when wearing the helmet. The team concluded that efforts should be made regarding helmet design, awareness, peer pressure and cost. More recent interviews with school children found a decrease in helmet wear as children got older and moved into secondary school (Berg & Westerling, 2001).

A 2017 study in the UK found 14% of those surveyed cycled at least once a week (Department for Transport, 2018). Although there are many health benefits associated with cycling regularly such as cardiovascular exercise and means of transportation, research has showed that it still may present opportunities for injury (Oja et al., 2011). In 2018 around 17,500 cyclists reported at least minor injuries, including 99 fatalities. Although numerous, this is likely an underestimation as this only includes those which occurred on roads and were reported to the police (Department for Transport, 2019; The Royal Society for the Prevention of Accidents, 2014).

Multiple studies have found that wearing a helmet can reduce the risk of serious head injuries for all ages when compared to not wearing one (Attewell, Glase & McFadden, 2001; Finvers, Strother & Mohtadi, 1996; Maimaris, Summer & Tummer, 1994; Rivara, Thompson & Thompson, 2015). This is particularly important for children who are more likely to sustain injuries to the head and face due to not being fully developmentally matured in balance and coordination (Rivara et al., 2015). Although wearing a helmet has not been found to prevent other serious injuries, such as fractures, they are proven to lessen the severity of serious brain injuries that are likely to have graver long term effects (Finvers et al., 1996; Shafi et al., 1998). This research acknowledges the fact that that wearing a helmet can provide a ‘false sense of security’ causing less attentiveness and caution. This phenomenon could in itself put individuals at risk of sustaining serious injuries in an accident (McCarthy, 1992).

Compiled research suggests that helmet usage varies drastically around the world, and further differs in between age groups. Countries such as Australia, New Zealand and Spain mandate the use of helmets when riding a bike for all ages (Lee & Mann, 2003). Studies in Ottawa (Canada) and Oxford (UK) found helmet usage was 32.5% and 26.5% respectively (Cushman, Pless, Hope & Jenkins, 1992; McGuire & Smith, 2000). In understanding distributions within age groups, Cushman et al. (1992) found that 44.6% adult commuters wore a helmet compared to just 21% of students. The distribution within student groups varied significantly: Primary Schools [2 - 68%], High Schools [4 - 36%]. These low usage rates amongst youths were corroborated by Weiss (1986) who found less than 2% of school aged children wore a helmet. The team understands that these studies are limited by their dates and the likelihood that over time trends and educational awareness have adapted. Caution is also taken to avoid inappropriately extending these findings to other countries or regions at that time. Recent studies have continuously supported the above findings, as a UK based study found that only 17% of 8-12-year olds always wore a helmet (Lang, 2007). This highlights the potential population of youths that may be exposed to an increased risk of severe head injuries.

In compiling and analyzing the findings, the team has concluded that limited participation rates in wearing cycling helmets can be attributed to attitudinal factors and comfort. Children are highly perceptive to the opinions of their peers and may refute safety equipment if it contrasts to those around them. More importantly if equipment is uncomfortable, children will likely hold a strong opposition to wearing them or continuing with the activity (Lang, 2007; Loubeau, 2000). Further research pointed to socioeconomic factors that may further influence usage rates amongst children as Lang (2007) found that the likelihood of a child wearing a helmet decreased as the occupational social class of their parents decreased.

2.2. Global Market Research

Market research was focused on investigating the potential impact that a new product could have on the current market and potential limitations in the current market product offerings. A qualitative approach was taken to gathering as much information as possible from those buying and selling the helmets and cross referencing this with current research and literature. Interviews allowed for a rich and detailed finding which were used to develop key themes and concepts (Codó, 2009).

Early research indicated a potential correlation between market sizes and regionalized legislation that mandates cycling equipment for lower age groups (Esmaelikia et. al, 2018). An estimated 20% of the world's population is strongly encouraged or impacted by regulations requiring helmet usage. A large proportion of this population falls in the North American and European regions.

Based on estimated market sizes for North American and European regions, the leisure cycling industry is worth $44.4 billion with $1.02 billion isolated to helmets alone, Figure 1. This information was used to develop an initial launch strategy as to which markets to first align the brand launch.

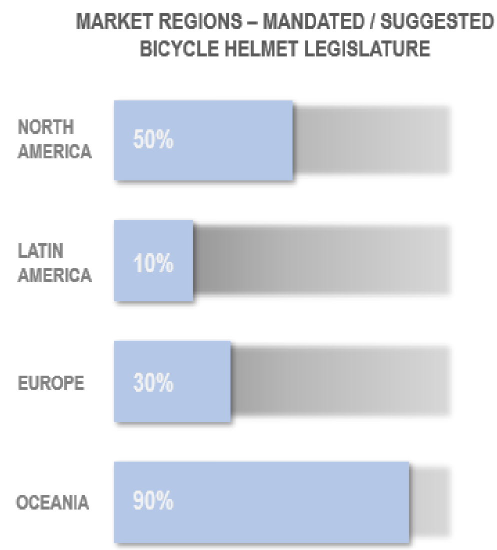

Figure 1 Quantified percentages of countries that have existing legislature or mandates requiring the wearing of helmets for youths (<16 yrs. old)

2.3. Industry Safety Standards

The team identified the mandatory and premium safety protocols found throughout the industry. Table 1 outlines the most prevalent standards found amongst industry leaders for compliance in the final design of this project. Along with safety compliance, the final design will comply with size designation 495 (A) of BS EN 1080:2013 testing protocol released by British Standard Issuer for Impact protection helmets for young children.

Table 1 Summary of Relevant Industry Safety Standards

Safety Standard	Associated Governing Body	Description
EN 1078 (European standard, 2012)	British Standard Issuer	European standard for helmets. Includes the following tests: Anvil test, drop apparatus test, flat anvil drop test, impact energy criterion, roll-off test and retention system strength test.
EN 1080 (European standard, 2012)	British Standard Issuer	European standard for kids' helmets. Tests if the helmet is designed to avoid strangulation while usage.
B-95C (Standard for Protective Headgear for Use in Bicycling, 1998)	Snell Memorial Foundation	Stringent and kids' specific safety standard for helmets inclusive of extreme test cases.
F1952-15 (American Society for Testing and Materials, 2002)	American Society for Testing and Materials	Tests designed to expect the helmet to withstand impacts higher than Snell and British standards.
CAN-CSA-D113.2-M (Standard Council of Canada, 2014)	Canadian Standards Association	1996 amendment of the safety standard included safety tests for kids' helmets.
JIS T 8134-1982 (Japanese Standards Association, 2007)	Japanese Industrial Standard	Testing of helmets before and after a process of conditioning.
AS/NZS 2512.1:1996 and AS/NZS 2512.9:1996 (Standards Australia/ Standards New Zealand, 1996)	Australian and New Zealand Standards	Provided information about methods of testing bike helmets and standards to be met for load distribution in cycling helmets.

2.4. Research Methods

Following a thorough literature review, the team launched a phase of consumer and industry expert interviews. The first interviews used a semi-structed protocol containing open-ended and broad questions directed at parents or guardians of children who would be purchasing the helmet. Interviews were to be undertaken with parents, as the emphasis was being placed on helmet purchase as well as the wear of the helmet. Websites are openly available for those purchasing children's helmets, with trends supporting luxury or high-quality helmet styles that boast optimum safety and features compared to the mass market

(Cunningham, 2019).With this in mind, questions were structured to investigate with how much parents would be willing to spend on helmets, and the safety concerns they may have. Additional questions included the age of children when they started to ride a bike, and what motivated the parents to teach them. The second element of the interview process was directed at bike shop workers. This was to gain an informed insight regarding the sale of bike helmets. Questions were also directed at the cost, but also general observations made when assisting the sale of bike helmets. It was decided that despite children being the end users, children would not be interviewed as they would likely not be buying the helmet and young age limit the amount of useful feedback they could provide.

2.5. Compiled Findings

The first cycle of interviews highlighted fit, safety, price and aesthetics as key themes. Interviews with both parents and shop workers provided similar findings such as the fit and the safety of the helmet being a primary concern. Example quotes are provided below:

"A comfortable chin strap causing concern of restriction to the airway'' Parent

"The strap could not be adjusted … because it caused an itch" Parent

"The chin strap is quite difficult with young kids to actually get on and be tight enough without … restricting their airway" Shop owner

"If it doesn't fit it just won't work" Shop Employee

"Only recently has there been a trickle down of safety standards such as MIPS'' Parent

"Cost does not matter if it is safe…'' Parent

''… it was literally 'which one will fit him?'' Parent

"there was a real lack of choice … so it was just trying to find one small enough" Parent

Wearing an ill-fitting helmet is a common problem amongst cyclists with 21% of children under 13 being observed to wear their helmet incorrectly (Hagel, Lee, Karkhaneh, Voaklander, & Rowe, 2010). An especially relevant finding for the target market was that younger children were more likely to wear a helmet than was too wide for them compared to older children (Rivara, Astley, Clarren, Thompson, & Thompson 1999). Indicating a possible gap in the market for cycling helmets aimed at younger children which are narrower. Another area mentioned in academic research and our interviews for ill-fitting helmets is straps not being tightened properly (Hagel et al., 2010) as well as being uncomfortable.

Academic research also added more than just anecdotal evidence that ill-fitting cycling helmets were not as safe with studies finding that people who wore a correctly fitting helmet, that remained centered in an accident, were less likely to incur a head or facial injury than those who's helmet was tilted too far backwards, tilted too far forwards, shifted during or came off in an accident (Hagel et al., 2010; Rivara, et al., 1999). Similar key considerations were stated by The Royal Society for Prevention of Accidents (2018) including affecting visibility and ventilation.

Parents in all cases stated that price was not a significant barrier, and that they would be willing to pay any price for premium safety. However, this may be an example of social desirability bias, a scenario where the interviewees are not giving the full truth as they are only saying what they feel they should say (McNeill, Puleo, Bennett, & Emmons, 2007). This limitation was highlighted by shop workers confirming price was a deciding factor upon their observations. The team also understands the limitation of a small sample size and use of convenience sampling so is cautious in expanding assumptions to all markets.

Appearance was also mentioned by shop workers and parents that it was a key factor that children looked for in a helmet, so every effort was made throughout the design process to make sure the helmet looked aesthetically pleasing to children.

Following the analysis of the first cycle of interviews and key theme development, further interviews took place with parents and bike shop workers to revisit the parent's perception of cost and to also discuss prioritizing the four keys themes that developed through synthesizing consumer research.

Based on consumer interviews and literature research, the team conducted a frequency analysis from transcribed copies of the interviews to determine the four pillars that best embodied the most commonly discussed views and findings. These pillars were used to define and shape the user profile to ensure a relevant and appropriate design was created.

2.6. User Profile

The design phase of the project started by identifying pre-defined customer segments that purchase children's bicycle helmet. This information was then parsed and organized to determine an informed user profile to center the design process around. The initial assumption used was that many individuals learn to ride a bike at a young age. The team understood that it was a crucial exercise to understand the primary stakeholders, their own motivations, and decision processes when purchasing a child's helmet. With an HCD approach, this compiled knowledge shaped the direction and design of the helmet with added benefit to insights regarding styling and financial components. The primary product design wanted to optimize the implementation of industry safety standards while addressing any existing barriers that limit the participation of early stage youth cycling or usage of helmets.

2.7. Impact of Research on Design Process

Following the literature and interview review, the helmet design required a stronger retention system to enhance comfort and safety. Insightful user responses led to the decision to integrate adjustable magnetic clasps for ease and comfort when securing the helmet.

As all interviewed parents claimed that their children wear a helmet when cycling, secondary sources had to be used to establish children's reasons for not wearing a helmet. Loubeau, (2000) identified key reasons why children aged 12-13 didn't wear helmets were appearance and discomfort. Discomfort caused by overheating can be mitigated through effective ventilation (Alam et al., 2010). Initial conversations also uncovered that girls with long hair can be discouraged as hairstyles may create obstructions to the fit. As a result, a ponytail hole was integrated to encourage more girls to cycle while wearing a helmet.

3. Final Design

Through interviews, research, and consumer insights the team determined fit to be the most significant and quoted factor in purchasing and continuing to wear a helmet. All else, features or materials, are rendered irrelevant if suitable fit is not achieved. Therefore, the team honed the design focus to implement an optimized fit while accounting for various head sizes, shapes, and hair. Later discussion will describe how additional features, such as padding and retention systems, contributed to solving this design criteria.

3.1. Design Process – Iterative Looping

After compiling a sufficient depth of consumer profile knowledge and industry related literature, the team was prepared to move onto the next phase of design, prototyping. Starting with rough sketches of helmets and clay models, the team explored what features were derivatives of a classic helmet and what new innovations could be implemented. Lights situated on a front visor and high quantities of ventilation holes, were some of the ideas discussed. The team utilized this opportunity to creatively express the facts and figures that had been uncovered from early stages of research. The team then debriefed by using 3D CAD formats to describe unique features. Each group member had creative freedom in what their helmet would look like as long as it was still a recreational bike helmet. This creative flexibility gave the group a variety of designs to work from and would prove insightful once the elements were combined into a cohesive final design. Based on current helmet designs it seemed like the placement and shape of air holes were variable. Taking these initial sketches, the team implemented the themes into Solidworks, which led each design to having unique hole shapes, sizes, and amounts.

The following infographic provides a high-level chronological detailing of the iterative design loop that the team followed.

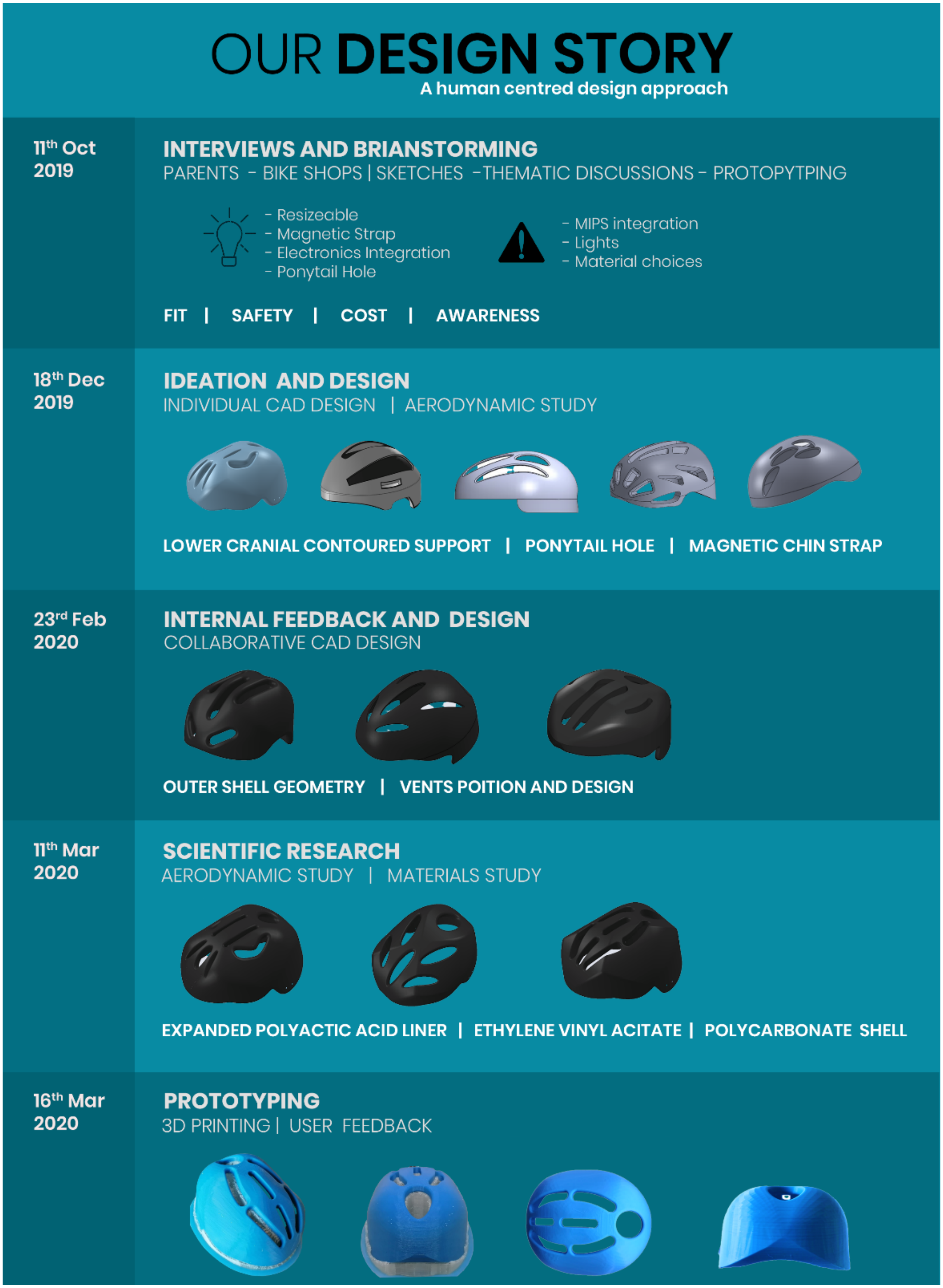

Figure 2 Chronological timeline of the team's design from initial brainstorming and ideation through the first designs, iterations, and the final prototype

3.2. Computational Fluid Design - Simulation

The first CAD iterations were taken into ANSYS Fluent Software to simulate airflow interactions during use. From these simulations it was determined that the location and size of the holes had a large impact on the aerodynamics of the helmet. Although it had seemed that the placement was arbitrary, future designs would need to be more cautious of air holes. The simulations also showed problems with the helmet shape of certain designs leading to flow separation and stress concentrations. Using this information from each of the five designs, the group created a new design brief with features that were desired as part of the helmet based on what was successful in certain designs as well what consumers wanted. From this design brief each member was tasked with creating a second helmet iteration. The goal of this iteration was to choose one helmet design that most accurately fit with what the team wanted the helmet to be. After choosing one of these designs, the group went back to do an additional iteration using the same CAD file but adjusting the smoothness of the shell and the hole shapes and placement. After

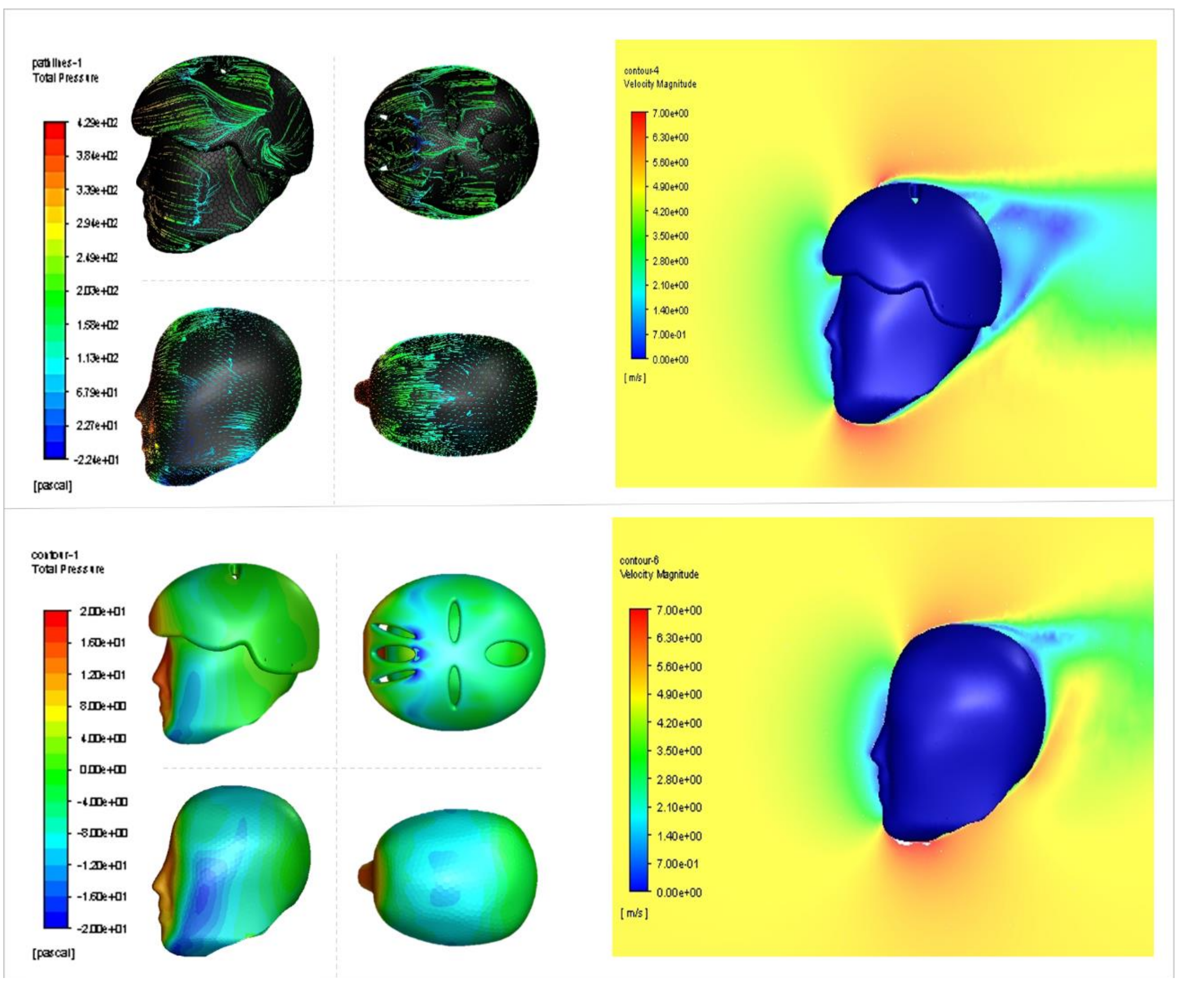

Figure 3 Summary of CFD simulation of the first helmet iteration that most influenced the final shape of the helmet as well as the bare head for comparison. Top Left: Total Pressure Vector Lines, Bottom Left: Total Pressure Contour, Right: Velocity Magnitude Turbulence.

comparing all of these iterations, elements were taken from each design to create a cohesive collaborative vision of the helmet.

3.3. Prototyping the Final Design

This final design was 3D printed in an ABS medium using the CSER laboratories. After receiving the prototype, it was determined that the thickness of the shell was greater than what was needed. Especially since the internal padding was not part of the printed design. In addition, due to the CAD design the surface of the helmet had more edges and faces than the actual helmet should have. Despite this, the prototype was a close approximation and offered a tangible tool for conversations with potential consumers and contacts.

3.4. Prototyping - Consumer Feedback

Following the design process, given the importance of feedback within the design process, final designs and prototypes were shown to the parents who gave their thoughts on the new helmet. Initial impressions and thoughts on the features included were mostly positive, some key quotes are shown below.

"looked quite smart and professional"

"all the kid's helmets are a little bit of polystyrene so if you've got something a little bit more advanced than that I think you're already on to a little bit of winner"

"the ponytail hole that's quite a clever idea"

[referring to magnetic chin strap] "That actually sounds like a really good idea".

The price that parents were willing to pay (shown below) indicates that the price is at a suitable level in the market and is in line with customer expectations.

"If it was genuinely ... shown to be of a better quality … I probably wouldn't blink at spending £50."

"I would be willing to pay somewhere in between £30-£40".

Some areas of concern were raised by the parents (shown below) with these mostly referring to adjustability of the helmet to ensure their child did not grow out of the helmet too quickly. This led to the addition of the retention fit system to ease these concerns.

"Was that finished apart from obviously all the straps and things or was there an additional coat or design to go on it?"

"Is there any scope within it for adjusting it as kids grow?".

Based on the feedback from the parents, necessary changes were made, and the design was finalized and decisions for the materials used were made.

3.5. Features and Design

The following sections will describe the features and their functionality, and how they ultimately contribute to the end goal experience for the user.

3.6. Compressive foam

The two foams used are sustainable and economic for the considered application. The first foam is Expanded Polylactic Acid (EPLA) which is a dense crushable foam that makes up most of the body of the helmet. The second foam is Ethylene Vinyl Acetate (EVA) which is a softer shock absorbing material which is often used in sporting equipment. EVA has good water and moisture resistance which is important as the padding may be exposed to moisture and sweat as it sits directly on the user's head (FOAMTECH, 2017). EPLA makes up the majority of the helmet but only represents ~24% of the overall manufacturing cost.

3.7. Ventilation

In exploring various ventilation orientations, the final design pursued an array of 7 holes inclusive of a cavity that allows hair adaptations such as ponytails to still be easily worn during wear. Ventilation holes are needed to provide cooling and airflow to the rider. Through CFD analysis of previous designs the team determined what the optimal size, shape, and placement of the holes would be. Larger holes allow for more airflow but lead to the risk of debris entering the helmet. Holes with sharp edges or breaks in the middle lead to vortex formation and increased drag. Evidence of such vortex formation can be found in Figure. Finally, it was determined that holes on the top of the helmet were better than on the side, as those on the side caused flow separation. The number of holes was an arbitrary number chosen by the team intended to provide airflow without compromising safety related surface area.

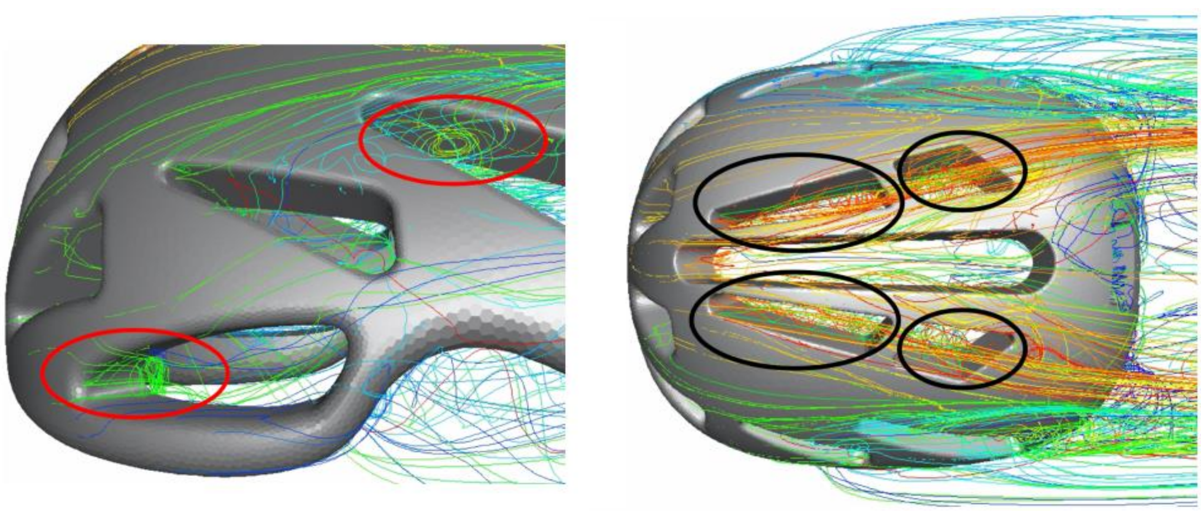

Figure 4 CFD results from one of the first helmet iterations that provided the most insight into the shape and placement of the ventilation holes. Circled regions show areas of vortex formation.

3.8. Hardware

Additional hardware components included magnetic closure straps to promote a safe and secure system that mitigates snag risk when closing its buckles. The system will release after sustained pressure to prevent choking and injury. The chin strap is still simple enough that the child can lock and unlock it independently. Notable comments from interviewed consumers shared the sentiment of frustration in accidentally pinching skin when trying to adjust buckles. Additionally, the design integrated an adjustable retention fit system which allows for a quick and easy adjustment to the nominal fit of the helmet that can be adjusted as the child grows.

3.9. Ergonomic

The features chosen for this helmet were designed to best fit the needs and desires of the consumer based on research and interviews, both for ease of use and safety. This assembly was chosen due to identified market offering gaps. As previously stated, the magnetic chin strap mitigates snag on the user's skin which can cause pain and discomfort. Further identified concerns is fit, and the concern that the child will grow out of the helmet too quickly. By having a tension adjusting retention system, the user can get more use of the helmet without sacrificing fit which is essential to safety.

3.10. Materials Selection

The helmet will be a multi-layered design to provide the highest level of safety and the best fit possible. The helmet shell will be made from polycarbonate with a scratch resistant coating. The first protective layer will be Expanded Polylactic Acid (EPLA) liner, followed by Ethylene Vinyl Acetate (EVA) padding.

3.11. Materials - Outer Layer

Polycarbonate and acrylonitrile butadiene styrene (ABS) are industry leading standards used as shells for bike helmets. Both materials are strong and impact resistant thermoplastic materials. Thermoplastics allow for the material to be heated and easily shaped without altering its chemical structure and material properties. This means that a helmet shell could be easily manufactured through injection moulding or 3D printed. Thermoplastics are also widely recyclable, allowing the team to capitalize on sustainability. Compared to ABS, polycarbonate is stronger, more impact resistant, but is more expensive. Although ABS is scratch resistant and polycarbonate is not, a scratch resistant resin can be used to coat polycarbonate to alleviate this concern. While polycarbonate weighs more than ABS, the additional weight should not adversely affect the user as this material has been used in other helmets for children of the same age as what this design focuses on. Polycarbonate will be used for the shell as it is a stronger and safer material (TeamFold, 2020).

3.12. Materials – Mid and Inner Layers

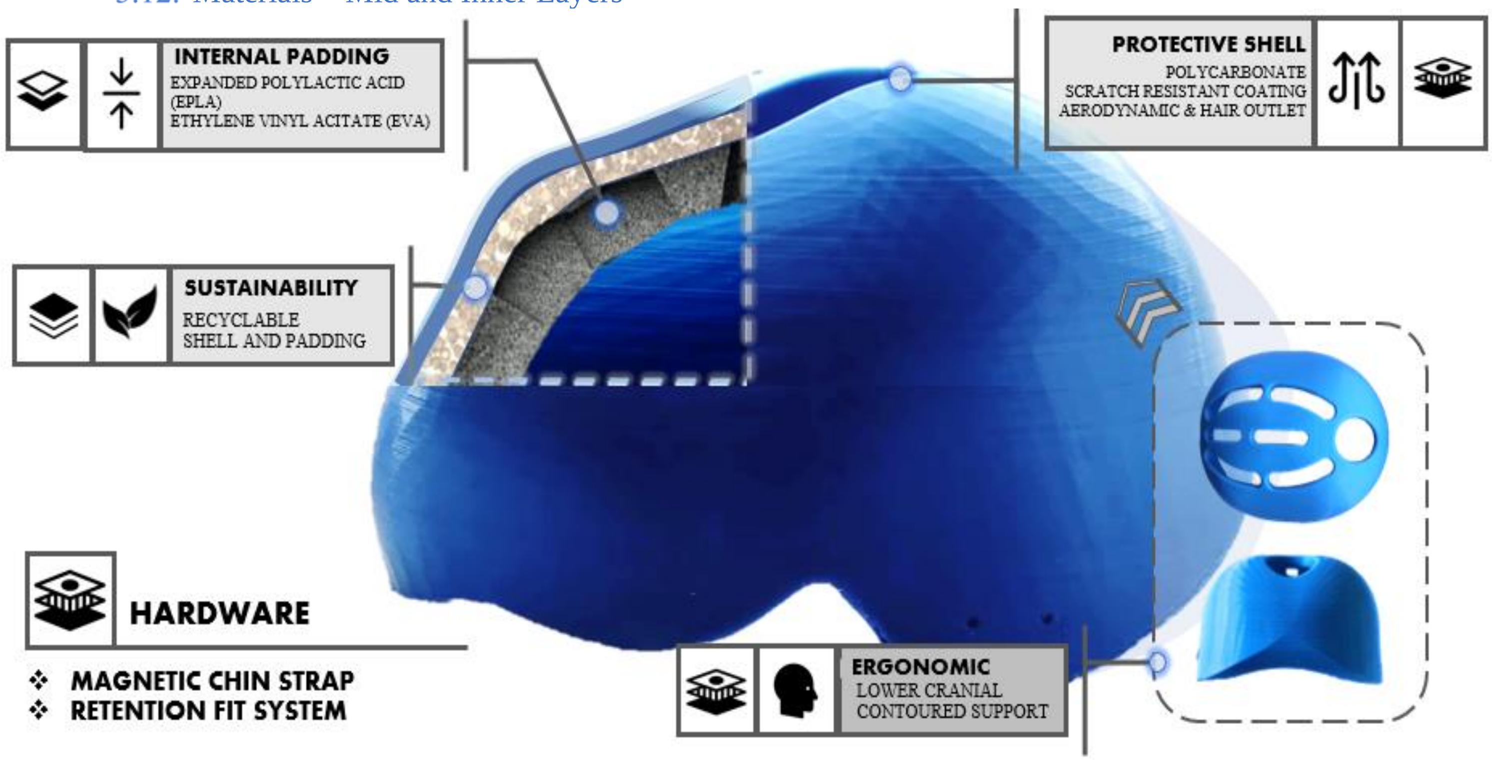

Figure 5 Final helmet design and feature breakdown showing the different layers, materials, and safety considerations that went into the creation of the helmet. Layer thickness is notshown to scale.

Expanded polystyrene (EPS) is the industry standard for a crushable foam helmet liner. These crushable foams are designed to compress and absorb energy from impacts but are most effective for very hard impacts. EPS is often used as it is cheap, lightweight, and possesses optimal characteristics for impact. While it is possible to recycle EPS, only certain facilities can do it, and the resources it takes to recycle the material is more than what is being saved from the recycling in the first place. Instead of EPS, EPLA can be used as a crushable protective layer as it has comparable characteristics to EPS while being biodegradable. EPLA allows for a more sustainable helmet without sacrificing safety (Parker, 2011). While additional layers will increase the thickness of the helmet, the EPLA performs better for hard impacts. This is not deemed as a high concern as the intended users will experience lower grade impacts. Another protective layer of a softer foam will help with milder injuries. For this padding, the team is using EVA which is a softer shock absorbing material. The EVA padding is replaceable increasing the lifespan of the helmet. There are other materials such as Koroyd that provide high levels of safety and ventilation that could be used to replace both the EPLA and EVA. However, these materials are very expensive and are designed for helmets experiencing powerful impacts such as those seen in off road cycling. Since this helmet is for kids it is not cost effective to use materials like that. The team strongly considered an additional MIPS layer as it would provide extra protection and fit adjustability. However, cost rendered it out of scope for the current model. As is common amongst current market offerings, if the polycarbonate cracks or the EPLA breaks, the helmet must be recycled and replaced.

3.13. Mass Analysis

The 3D printed prototype of the helmet of 10mm thickness including the inner layers weighed 456g – 496g from mass analysis estimates. Based on feedback and design iterations the outer shell of the helmet was reduced to 5mm thickness and the overall helmet weighed 254g from mass analysis estimates. The extremely light inner lining of E-PLA (mass density: 30 kg/m3) helps keep the helmet light. Figure 6 shows how the design compares in weight other competitor helmets.

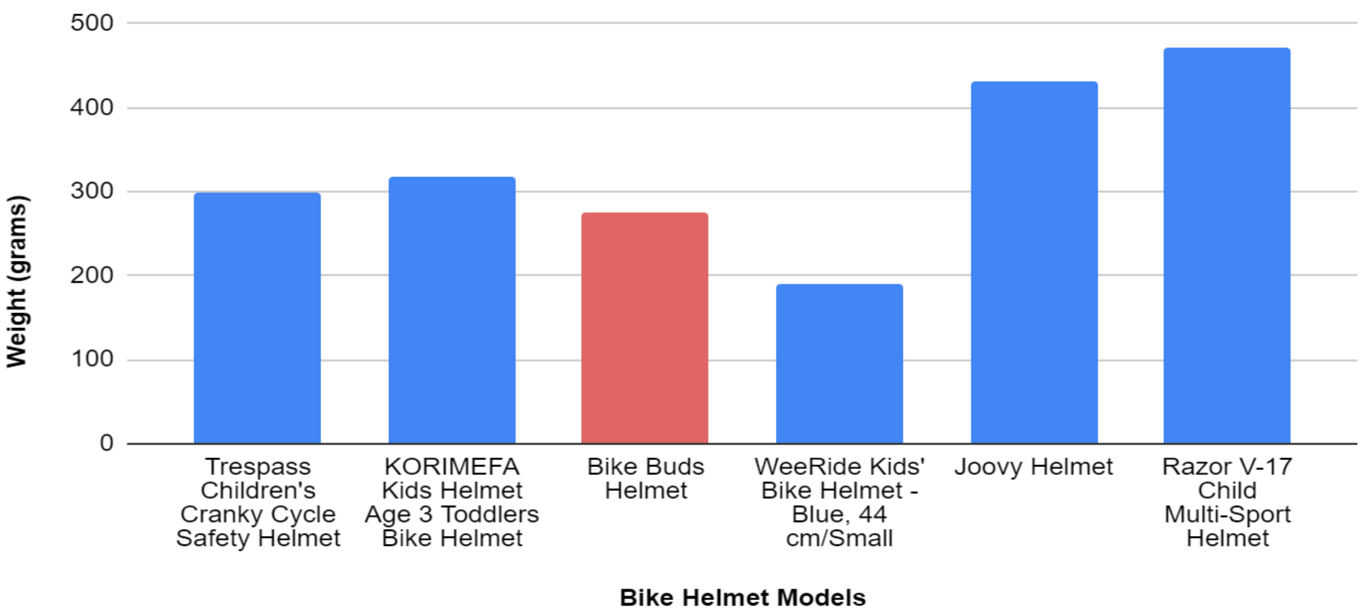

Figure 6 Mass analysis of the team's final design compared to that of current market competitors

3.14. Manufacturing and Cost

In summary, the helmet will be composed of a polycarbonate shell, EPLA body and EVA padding as illustrated in Figure 5. The shell will be formed through injection moulding of polycarbonate into the shell shape and then protected by a scratch resistant coating. Reflective tape will also be placed on the shell to aid in visibility of riders especially at night. Materials cost and manufacturing for the outermost layer comes to $4.50. The second layer is the main EPLA body which is formed by moulding the EPLA and its total cost is $3.50. The EVA pads are being purchased from a tier 2 supplier and will cost $1.70. The retention system costs $4.10 and the magnetic chin strap and fasteners costs $4.57. This leads to a helmet that will cost $18.87 to manufacture when adding in $0.50 to assemble the helmet. This cost and manufacturing breakdown can be seen in more detail in Appendix B.

4. Business Profile

Bike Buds has created an integrated product for youths across levels of expertise and profiles to safely enjoy riding bicycles and related activities. The following section will outline essential business structures related to the upward scaling and launch of the product. Through developing the business profile, the team has acknowledged areas of strength and potential improvements. This analysis is put in the form of a SWOT chart and available below. The team will mitigate areas of weakness with contracting specialists and capitalizing on the novel offering through aggressive and widespread marketing campaigns.

Table 2 Strengths & Weakness Analysis

	Helpful	Harmful
Internal	❖ Product targets gap in market ❖ Manageable team relations ❖ Research / development facilities	❖ Establishing material cost for target consumer ❖ Limited knowledge in industry
External	❖ Strong community network ❖ Large potential market driven by legislature ❖ Demographic easily identifiable	❖ Large established competitors ❖ Undeveloped brand awareness ❖ Consumer resistance to wearing safety gear

4.1. Main Competitors:

This product targets a middle ground solution to be strategically segmented between standardized mass producers and novel specialty manufactures. Although this creates a wider array of competitors, it also provides an opportunity to unify the accessibility of economic models while boasting design functionality of higher end models.

Table 3 Market Competitor Analysis

Market Segment	Manufacturer | Model	Highlighted Features	Price [USD]
Specialty	Bell – Character Bike Helmet	Popular Children's Character designs/3D animations	24.99
General	Bell Rally Child Helmet	1-Step Adjustment System	16.99
General	Razor V-17 Child Multi-Sport Helmet	Ergonomic Cooling / Side Buckles	17.21
General	Giro Scamp Youth Bike Helmet	Rugged Engineering/ Pony-tail Compliant / polycarbonate shell	39.95
Specialty	Joovy Noodle	Pinch guard chin strap / adjustable retention fit	28.00
Specialty	Team Obsidian Kid Helmet	Adjustable retention fit (from toddler to children) / Internal padding and EPS	35.97

4.2. Relevant Market Patents:

The following patents present cases of parallel design processes. Although, initial research has found no credible obstacle to filing a design right or impeding a product launch in its current stage.

Table 4 Patent Summary and Relevant Threat Levels

Patent Name	Filing	Description	Threat Level
US7802319B2; Helmet with rearward access aperture -	USA	A multi-layered hard-shelled full-face helmet with a posterior aperture.	LOW
US2991478A; Safety Helmet	USA	Hard outer shell with straps intended for all weather conditions and increased ear protection.	LOW
US6401261B1; Sizing and stabilizing apparatus for bicycle helmets	USA	Bicycle helmet with articulated elastic / flexible members that add additional pressure to the wearers head.	LOW

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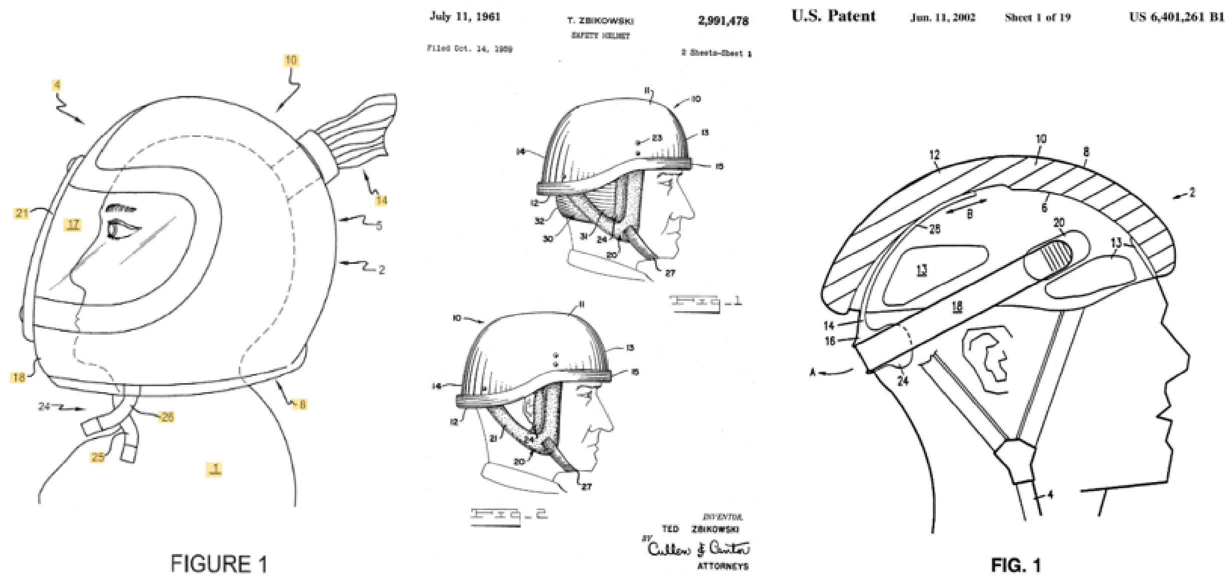

A **B** **C**

Figure 7 Relevant existing patents that present cases of parallel design processes

From Left to Right: [A] Helmet with rearward access aperture, [B] Safety Helmet, [C] Sizing and stabilizing apparatus for bicycle helmets

4.3. Business Model Canvas

The following section will discuss in detail the segments of the business model canvas relating to the product integration strategy. This content will act as a summary in calling upon content from previously mentioned sections as seen related. A full visualization of the business model canvas can be found in the Appendix.

4.3.1. Key Activities

Following the design process, the team will begin a full implementation leading up to a full product launch. The following key dates will act as milestones in the product life cycle. Necessary adaptations to the timeline will be addressed upon occurrence.

Table 5 Anticipated Product Launch Timeline

Date	Milestone	Description
June – 2020	Final design	Final iterations, BOM, and component interactions will be defined and scoped out for manufacturing.
August – 2020	Established Manufacturing Flow and Partnerships	The necessary manufacturability scoping and logistics will be formulated and contracted.
October - 2020	Initial Limited Run for Beta Testing	First run of ~ 500 units will be produced for initial testing and review.
March – 2021	Obtained necessary Safety compliance awards / IP	Relevant safety compliances and IP will be officially met and registered with organizations listed in previous sections.
March - 2021	Finalized e-commerce site and initial distributer POS	All relevant IT systems, digital marketing, and distributer wholesale relationships will be facilitated and approved for product launch.
May – 2021	Product Launch in NAM/Europe Markets	Full product launch will be reached with logistics, customer service, brand management working at full staffed capacity.

4.3.2. Key Partnerships

Bike buddies has worked in strong partnership with the available research facilities at Sheffield Hallam University. This academic network has proven to be, and will continue as, one of the primary partnerships of the launch. Other strong partnerships will be formed with advocate groups for youth cycling safety and regional niche storefronts for commercial distribution. Current supervisors will remain mentor partners and act as key partners in advising scientific validation studies.

4.3.3. Key Resources

Key resources are categorized as Intellectual Property protection, manufacturing and strategical insights. Bike buddies will pursue a Design Right in relevant regions, as the product is unique of design and not innovation. Estimated incurred costs have been included in the Break-Even Analysis. This will limit the assets allocated to IP while optimizing the integrity of the brand post deployment. Manufacturing resources begin with those used to prototype and test: CSER 3D printers, material testing devices, CAD software, and CFD packages. Future key manufacturing relationships will be established as key resources.

4.3.4. Value Propositions

As previously mentioned in the introduction of this document, Bike Buds is presenting a novel design approach of integrating fit and safety into a youth helmet that motivates and welcomes recreational cycling. The product offers protection, lower rear support, dual pony-tail compliance, ventilation. This combination of features offered at a mid-market pricing provides a competitive market placement that addresses the needs of both youths and parents. The product allows parents to enjoy the experience of helping the young ones learn how to ride a bike to the phase of youth recreational independence.

Company will provide inclusive community to learn about training techniques and how to engage with your family members through cycling

4.3.5. Customer Relations

The Bike Buds brand encourages the enjoyment of families in cycling together. An essential goal is to develop a product that easily integrates with user's habits, and one that encourages other users to learn how to ride a bike. Deemed as a beginner's helmet, the brand will look to launch partnered initiatives to share educational content as to best practices when learning how to ride a bike and a platform for community members to share their experiences.

4.3.6. Channels

Working off of a three-tiered deployment strategy, Bike Buds will look to enter the market through: online commerce, direct distribution through niche store fronts, trade show/conventions. There will be an emphasis of point of sale through online commerce to grow international exposure and reach a broader community.

4.3.7. Customer Segments

Customer segments include but are not limited to eco-conscious parents, avid cycling families, parents of young children. Further analysis of customer segments may be referenced from the user profile in previous sections.

4.3.8. Cost Structure

Bike Buds will operate on a unit sale model where cumulative proceeds of sales will support the business. Product will be sold at a wholesale cost for within business trade and at full retail for all other points of sale (POS).

4.3.9. Revenue Streams

The primary revenue stream will be from fixed unit pricing as strategized from the cost structure and distribution channels. A full break-even analysis can be found in Appendix A with a supplemental Unit Cost breakdown in Appendix B. In order to begin earning revenue approximately 7,000 units will need to be sold.

Word Count: 5,340

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6. Appendix A – Break Even Analysis

Break-Even Analysis

Fixed Costs (Overhead):	**Unit Cost**	**#**	**Amount**	**Type of Cost**
Space lease	$8.50	600	$5,100	Annual cost [SQF]
Utilities (including phones)	$200	12	$2,400	Annual cost
Website Management	$30	12	$360	Annual cost
Product Liability Insurance	$1,950	1	$1,950	Annual cost
Manufacturing tools	$14,600	1	$14,600	Start-up cost
Marketing	$18,000.00	1	$18,000	Annual cost
Overhead salaries & benefits				
CEO/ Engineer	$80,000	30%	$0	Annual cost
CFO/ Engineer	$80,000	20%	$0	Annual cost
CTO/Engineer	$70,000	20%	$0	Annual cost
COO/Engineer	$100,000	15%	$0	Annual cost
CEnO/Engineer	$100,000	15%	$0	Annual cost
Office equipment	$5,375.00	1	$5,375	Start-up cost
Software	$8,000.00	1	$8,000	Annual cost
Legal fees	$250.00	12	$3,000	Annual cost for 3 years
Accounting fees	$250.00	12	$3,000	Annual cost
Graphic design	$2,000	1	$2,000	Annual cost
			$63,785	

Direct Costs Per Unit Produced:	**Unit Cost**	**#**	**Amount**
Unit Cost	$18.77	1	$18.77
			$18.77

Variable Costs:	
Sales commissions to CEO	7% of revenue

Retail Cost to Customer:	**$37.54**	Can be altered for sensitivity analysis
Wholesale Cost:(75% of retail)	**$28.16**	75% of retail
Retail: Wholesale Weighted Revenue/unit	**$30.03**	
80% Wholesale		
20% Retail via Internet		

Break-even analysis:		
Fixed Costs	$63,785	
Revenue/Unit	$30.03	
Direct Costs/Unit	$18.77	
Gross Margin	$11.26	
Variable Cost	$2.10	
Break-even Point	**6,964**	**(units that must be sold to begin making money)**
Break-even Revenues	**$ 209,131.15**	**(revenue required to begin making money)**

7. Appendix B – Bill of Materials

ITEM	DESCRIPTION	LAYER	UNIT QUANTITY	PRICE PER UNIT		MNFC. LOCATION | PROCESS	MANFC. COST	TOTAL	RATIONALE
Padding	Airsoft EVA Pads	INNER	1.0	1.60	Unit	T2 Supplier	$ 0.10	$ 1.60	(BraveWind BraveWind 27 Pcs/Set Helmet Padding Kit Bicycle Replacement Universal Foam Pads Set Universal Airsoft Helmet EVA Pads for Bike Motorcycle Cycling Helmet)
Retention System	Wholesale unit	INNER	1.0	4.00	Unit	T2 Supplier	$ 0.10	$ 4.00	(Aolikes Outdoor Tactical Helmet Accessories Paintball Suspension General Fast Adjustable Helmet Belt for Airsoft Hunting Climbing Helmet: Helmets: Sports & Entertainment - AliExpress)
Mid Layer Insulation	Bio foam Moulded	MID	100.0	0.03	USD/g	APAC FACTORY	$ 0.50	$ 3.00	(Symbra BioFoam Materials Specifications, 2020)
Reflective Tape	Wholesale unit	MISC.	0.5	0.10	USD/m	T2 Supplier	$ 0.10	$ 0.05	(Ningbo First Import & Export Co., Ltd., 2020)
Magnetic Clasp	License T2 Supplier	MISC.	1.0	4.00	Unit	T2 Supplier	$ 0.10	$ 4.00	Wholesale Approx.
Chin Straps	Wholesale unit	MISC.	2.0	0.03	Unit	T2 Supplier	$ 0.10	$ 0.07	Wholesale Approx.
Fasteners	Wholesale unit	MISC.	4.0	0.05	Unit	T2 Supplier	$ 0.10	$ 0.20	Wholesale Approx.
Outer Shell	Polycarbonate	OUTER	1.0	3.00	USD/LBS	APAC FACTORY	$ 0.50	$ 3.00	(TeamFold (2020) ABS vs Polycarbonate: Which Helmet Shell Material Is Better?)
Outer Coating - Scratch Resistant	UV-Cured Powder Coating	OUTER	1.0	0.35	USD/SQF	APAC FACTORY	$ 0.50	$ 0.35	(Sciences Advantages & Cost Analysis of UV-Cured Powder Coating) (Weetect, 2020)
Shipping / FOB		MANFG.					$ 2.00		
Assembly		MANFG.					$ 0.50		
Total								$ 18.77	
Mark-up								$ 37.53	

8. Appendix C – Illustrated Business Model Canvas