ELITE DEVELOPMENT GEAR

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DESIGN BY
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Accessible Training Devices for Young Hockey Players

by

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Thesis Summary Video

https://youtu.be/nD8o2xJpy9E

Physical Model Video

https://youtu.be/fglLuv7ovmA

CAD Modeling Video

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Abstract

In Canada hockey holds a central place in culture and identity, however accessibility to the sport has become an increasingly pressing issue. The high costs associated with equipment, training, league fees, ice time, and travel have limited the participation of youth from diverse socio-economic backgrounds. This problem not only restricts the sport's reach but also hinders the physical activity and well-being of Canadian youth. Elite Development Gear, designed for on and off-ice training, integrates with existing gear, offering solutions to challenges like limited training resources and ice time. It provides interactive technology and personalized feedback, aiming to enhance training experiences and overcome skill barriers. Elite Development Gear aids players in reaching their full potential, fostering a more inclusive and accessible environment for aspiring hockey athletes at all levels.

Keywords: Ice hockey accessibility, athlete development, hockey training, interactive sports equipment

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Table of Contents

CHAPTER 1

INRODUCTION

1.1 Problem Definition

1.2 Rationale & Significance

1.3 Background, History, & Social Context

CHAPTER #1 – Introduction

1.1 Problem Definition

Ice hockey holds a central place in culture and identity in Canada, however accessibility to the sport has become an increasingly pressing issue. The high costs associated with equipment, training, league fees, ice time, and travel have limited the participation of youth from diverse socio-economic backgrounds. Some players may not have access to effective and affordable training equipment that can significantly enhance their skills. Young players aspiring to compete at higher levels face barriers in accessing advanced training tools, which can hinder their skill development and overall competitiveness in the sport. This problem not only restricts the sport's reach but also hinders the physical activity and well-being of Canadian youth. To address this issue, this thesis will explore ways of improving accessibility to ice hockey and addressing the need for accessible and innovative training devices that cater specifically to the needs of youth hockey players. It considers the macro perspective of the sport's cultural significance in Canada and the need for inclusivity. At the micro level, the evaluation and analysis will involve observational studies, interviews, and surveys to understand the challenges faced by youth players, parents, coaches, and hockey organizations. These solutions will enhance the lifestyle of Canadian youth, improve ergonomics and user experience, and contribute to sustainability efforts. Ultimately, this research seeks to ensure that the unifying force of hockey in Canada is truly accessible to all, regardless of financial circumstances, fostering a healthier and more inclusive future for the sport.

1.2 Rationale & Significance

In this project, key information to be determined revolves around the current landscape of accessibility to hockey training for youth players. This includes understanding the existing methods and resources available for training, the effectiveness of these methods, and how well they cater to the needs of

young players. Also, important will being able to identify the preferred learning and training preferences of young players in order to create the most effective training tool.

The key questions that need to be addressed include the types of training equipment effectiveness and availability, specifically focusing on what young hockey players use and their preferences regarding these products. Understanding the features, they appreciate or dislike existing equipment. Additionally, the project will address the role of coaches and trainers in young players' development, investigating any challenges or shortcomings in the current coaching system.

1.3 Background / History / Social Context

For youth hockey training equipment accessibility, various big picture trends significantly impact user engagement and participation. The target demographic of youth hockey players aged 10-14 represents a critical segment in the sport, as this age group marks the entry point into Tier 1 hockey in Canada. Additionally, these players often dedicate a substantial amount of time to training and playing hockey, reflecting a lifestyle trend that emphasizes specialization in sports at an early age. Media trends play a role as well, with technology and digital solutions becoming increasingly integrated into sports training and development. Product trends in the sporting industry indicate a shift towards innovative and tech-enhanced equipment, aligning with the growing demand for high-performance solutions. Understanding these trends is essential in devising accessible training devices that cater to the needs of young hockey players and their evolving preferences.

CHAPTER 2

RESEARCH

CHAPTER #2 - Research

2.1 User Research

This section will include an overview of the context for this project. A persona is determined based on surveys, interviews, and observations. Research also includes activity mapping and benchmarking existing products.

2.1.1 User Profile - Persona

Primary users are young hockey players aged 10-14, displaying a diverse range of economic backgrounds and a strong interest in hockey and physical fitness. They dedicate a significant amount of their time to training and aspire to compete at the highest levels. Secondary users include parents and guardians responsible for supporting and facilitating the participation of young players, coaches who play a pivotal role in the development of these players, local hockey organizations responsible for managing youth leagues, and hockey equipment manufacturers involved in designing and producing hockey gear. Tertiary users encompass government authorities and sponsors supporting youth sports programs, scouts and talent evaluators identifying and nurturing talent, and various community stakeholders.

Takeaways from expert interviews:

- Registration fees, rep fees, travel costs (gas, food, hotels), and equipment provide a significant financial barrier to accessing hockey.
- They observed families and parent groups planning cost-saving measures and fundraising to ease financial burdens.
- An inclusive team environment is crucial in breaking down barriers in accessing hockey. They also highlight the importance of team sports for developing life skills.

- There are significant time commitments involved for both players and parents, highlighting the demands of practices, games, and travel. Acknowledges the sacrifices parents make to ensure their children's participation.

2.1.2 Current User Practice

In examining the current user practices within the target demographic of young hockey players aged 10-14, several key aspects have been identified. Regular tasks and procedures for these players include gearing up for practice, wearing skates, participating in on-ice drills, practicing skating techniques, interacting with teammates, and finally, taking off their hockey gear. These activities are characterized by a mix of excitement and physical exertion, as young players eagerly engage in their favorite sport. Non-routine tasks and procedures can vary widely depending on the specific drills and exercises set by their coaches. Context plays a significant role in shaping the experience, as the intensity and focus during practice can change based on factors such as skill development goals, coach feedback, and even the competitive spirit of the team.

2.1.3 User Activity Mapping

USER TASK MAP				
Task	Ergonomics - Safety & Comfort	Productivity (Efficiency)	User Interface	Ease of Use
Gear Up for Practice	Ensure gear fasteners are user-friendly. Optimize gear layout in the bag.	Design clear gear layout.	Visual guides for gear arrangement. Intuitive gear adjustments.	Simple fasteners and closures. Clear visual cues for arrangement.
Wear Skates	user bends down to use lacing system	fairly long and difficult process for youth to tie tight enough	laces and lace holes in boot	can be difficult for youth
Participate in On-Ice Drills	up to user to properly participate withouth straining and getting hurt	coach tells players the drills	Pylons on ice, coach draws on board	users must be able to understand coach to complete drills correctly
Practice Skating Techniques	up to user to properly participate withouth straining and getting hurt	coach tells players the drills	Pylons on ice, coach draws on board	users must be able to understand coach to complete drills correctly
Interact with Teammates		players talk to eachother on ice		scan be hard for players to hear if environment is loud
Take Off Hockey Gear	players able to reach all straps to take off equipment and store in bag	Logical sequence undressing. Efficient gear storage in different compartments	different compartments and pockets in bag	Easy-to-open gear fasteners. Simple gear removal sequence.

Table 1 – Activity Mapping

How Usability May Inform Design

- Ergonomics & Safety:
    - Safety Concerns: Ensure that gear is easy to use and fasten, unobtrusive and not distracting, can be used at high speeds.
    - Bending Considerations: Address the ergonomic aspect of users bending down during the lacing process for skates.
- Productivity:
    - Communication Efficiency: Enhance communication efficiency from coaches to players during on-ice drills and practice sessions.
- User Interface:
    - Communication Aids: Explore visual aids for effective communication between players and coaches.
- Ease of Use:
    - Easy to use on your own and without prior knowledge.

2.1.4 User Observation – Human Factors of Existing Products

In observing the practices and human factors related to existing hockey training equipment, it becomes evident that the primary focus is on enhancing the players' on-ice experience and skill development. Training sessions often involve a dynamic environment, where young players switch between various skating drills, puck handling exercises, and team interactions. The majority of these activities occur on the ice rink, where players transition from standing on the sidelines to actively participating in drills. The layout and design of the rink play a crucial role in facilitating these transitions smoothly, allowing players to move freely without hindrance.

Figure 1 – User Observation

Additionally, players frequently interact with a range of equipment and accessories during practice, such as skates, sticks, pucks, and protective gear. These items need to be easily accessible, lightweight, and comfortable to wear, ensuring that players can focus on their training without being encumbered by their gear. This observation highlights the importance of ergonomics, safety, and user interface design in the development of training equipment, as well as the need to address any usability issues that young players may encounter during their practice sessions.

2.1.5 User Observation – Safety and Health of Existing Products

Safety and health considerations for existing hockey training equipment highlight important aspects of user observation. When it comes to safety, there are potential hazards associated with hockey equipment, making adherence to safety standards essential to prevent injuries. These standards are established and regulated by various governing bodies, including national standards organizations like the Canadian Standards Association (CSA). Training equipment must meet these safety standards to ensure that young

players are adequately protected during practice and games. Moreover, the safety aspect extends to the design and usability of the equipment. It should be safe to use, unintrusive, and free from distractions to minimize the risk of discomfort or injuries resulting from improper use.

2.2 Product Research

This section delves into comprehensive product research, offering valuable insights into the existing landscape of hockey training equipment and related trends. Insights will be drawn from expert interviews, surveys, and online discussions on blogs and forums to provide a holistic understanding of user preferences and needs. Additionally, current products in the market will be benchmarked through interviews and evaluations. This research forms a crucial foundation for the design approach, ensuring that the solutions are informed by real-world user experiences and industry best practices.

2.2.1 Benchmarking – Benefits and Features of Existing Products

Initial research covered product categories and then specific products more relevant to this project.

Product Categories	Challenges
Hockey Protective equipment	- High cost - Children outgrow and need replacement often - Non-sustainable materials - Feels bulky and limits mobility
Hockey Skates	- High cost - Requires replacement as the user grows - Requires regular sharpening - Can only be used on ice - Difficult to break in
Roller Skates	- Learning curve - Safety concerns - Limited use to flat and smooth surfaces - Require wheel and bearing replacement - High quality comes with a high cost - Difficult to break in
Synthetic ice / shooting pads	- High initial cost - Requires maintenance - Not the same surface feeling as ice, which can be difficult to get used to - Tiles wear down over time - Causes more wear to skate blades
Skating treadmills	- Very high cost - Requires a large dedicated area - Learning curve - Safety concerns - Does not fully replicate the ice skating feeling - Requires trained technicians to maintain, repair, and operate
Shooting targets and tarps	- Durability - Requires ample space to set up - Limited to top shooting training only - Hard to translate to shooting in stride in real game situations
Rebounders/ Passing devices	- Durability - Hard to use with limited space - Difficult to transfer skills to actual on-ice play
Off-ice pucks/ stickhandling balls	- Often do not replicate the on-ice feel - Weighted stickhandling balls can weaken the stick blade
Stickhandling training: Superdeker, hockeyshot speed deke kit,	- Skill transferability - Durability - Cost

Table 2 – Product Category Benchmarking

Product	Description	Benefits & Features
 Scorched Ice	Attaches to hockey skates for critical data collection. Measures left and right skate movements, toe pitch, edge roll, and foot acceleration, enabling detailed stride analysis.	- Critical data collection at the point of action. - In-depth stride analysis for both left and right skate movements. - Measures toe pitch, edge roll, and foot acceleration. - Facilitates detailed improvement insights for skaters.
 Helios Core	Mounts on shoulder pads. Provides training recommendations for enhanced progress. Offers rankings by birth year, facilitating performance comparison among players in the same age group.	- Convenient mounting on shoulder pads. - Personalized training recommendations for quicker progress. - Birth year rankings for performance comparison. - Enhances motivation through competition with peers.
 HockeyTracker iPhone app for apple watch	App for iPhone that uses apple watch data to provide insights specific to hockey	-uses existing product user may own already. Provides key metrics: Automatic Shift Detection (including shift length, calories burned, top speed, and heart rates from each shift), Live In-Game Stat Tracking, Live In-Game summary of your last shift (duration, cals, distance, and avg speed)

Table 3 – Hockey Training Sensors Product Benchmarking

2.2.2 Benchmarking – Functionality of Existing Products

Scorched Ice is a hockey training sensor that attaches to the user's hockey skates, collecting critical data on skate movements and mechanics such as toe pitch, edge roll, and foot acceleration. It facilitates detailed stride analysis, offering valuable insights for improving skating technique. Helios Core, on the other hand, mounts onto shoulder pads and provides personalized training recommendations, enhancing the user's progress in hockey training. It also offers rankings by birth year, encouraging healthy competition

among players of the same age group. Lastly, the HockeyTracker iPhone app, compatible with the Apple Watch, utilizes data from the watch to provide hockey-specific insights, automatically detecting shifts during gameplay and tracking metrics like shift length, calories burned, top speed, and heart rates. These products collectively aim to empower hockey enthusiasts with data-driven tools to enhance their skills and overall performance on the ice.

2.2.3 Benchmarking – Aesthetics and Semantic Profile of Existing Products

The aesthetics and semantic profile of existing products in the field of hockey training sensors examined in this chapter are characterized by a blend of modern, technical, and functional design elements. These products prioritize a sleek and streamlined appearance, often featuring a combination of high-performance materials to convey a sense of durability and robustness. The color schemes typically align with the sport's traditional colors, with that main color being black.

For the semantic profile, these products convey a sense of innovation, precision, and advanced technology. They are designed to appeal to hockey players who seek cutting-edge solutions to enhance their performance.

2.2.4 Benchmarking –Materials and Manufacturing of Existing Products

These products prioritize the use of high-quality, durable materials to withstand the rigorous demands of ice hockey training. Common materials include impact-resistant plastics, reinforced polymers, and lightweight metals like aluminum. These choices ensure that the products are robust enough to endure intense training sessions, potential collisions on the ice, and impacts from hockey pucks. Manufacturing processes for products like Scorched Ice and Helios core include injection molded casings that house the sensors that collect and track data.

2.2.5 Benchmarking –Sustainability of Existing Products

Scorched Ice and Helios Core prioritize durability and performance over sustainability in their design and functionality. These products aim to deliver long-lasting, high-performance experiences for hockey enthusiasts. On the other hand, the Hockey Tracker app takes a sustainable approach by utilizing existing technology, ensuring that users can access valuable insights with the devices they already own. Sustainability is not yet a dominant theme across all products in this product category, there is a growing awareness of the need for environmentally responsible design and manufacturing.

2.3 Summary of Chapter 2 – Topic Understanding

The focus of this chapter was on conducting comprehensive user research to gain a deep understanding of the target audience's needs and practices. This involved creating a detailed persona based on surveys, interviews, and observations, shedding light on primary, secondary, and tertiary users, including young hockey players, parents, coaches, organizations, and manufacturers. Expert interviews revealed the financial and time commitments involved in hockey training, emphasizing the significance of addressing these challenges.

The chapter further delved into current user practices, highlighting regular and non-routine tasks, along with the influence of context on the overall experience. Activity mapping provided valuable insights into usability considerations such as ergonomics, safety, productivity, and user interface, setting the stage for user-centered design.

The chapter also covered product research, including benchmarking of existing hockey training equipment. Product categories and specific products were examined, revealing challenges such as cost, sustainability, and usability. Three products, Scorched Ice, Helios Core, and the HockeyTracker app, were benchmarked in detail, elucidating their features, functionality, aesthetics, and materials.

In summary, Chapter 2 provided a comprehensive foundation for the design process by elucidating user needs, current practices, usability considerations, and insights into existing products in the hockey training equipment landscape. This user-centric approach ensures that the subsequent design concepts are well-informed and tailored to address real-world challenges and preferences.

CHAPTER 3

ANALYSIS

CHAPTER #3 - Analysis

3.1 Analysis – Needs

This section delves into the insights garnered from Chapter Two's research. It begins by utilizing insights from sections 2.1.3 and 2.1.4 to identify gaps in the current market offerings. These findings will are used to make needs statement that aligns with the central thesis problem.

3.1.1 Needs/Benefits Not Met by Current Products

Several crucial needs are not met current products in the realm of hockey training equipment. First and foremost, there is a persistent need for affordable training solutions that cater to a diverse user demographic. Current offerings often come with high costs, creating financial barriers that hinder many individuals, particularly those from economically disadvantaged backgrounds, from accessing quality training resources. Additionally, many current products often lack innovative training features that surpass traditional methods, limiting the potential for skill development and engagement. Furthermore, there is a latent need for real-time performance analytics to provide players with comprehensive skill assessments, which is currently lacking in available equipment. Finally, there is a growing demand for sustainable and eco-friendly materials to be used in equipment, aligning with environmental and ethical considerations.

3.1.2 Latent Needs

Latent needs include the integration of social features within the products to foster team bonding among young hockey players. This emphasis on social integration recognizes the importance of building strong team dynamics and friendships within the sport. Additionally, there is a latent need for real-time performance analytics to provide in-depth skill assessments, enabling players to monitor their progress and make data-driven improvements. Moreover, sustainability and eco-friendliness have emerged as a latent

need, highlighting the importance of using environmentally responsible materials in the design and manufacturing of hockey equipment. These latent needs reflect a more comprehensive approach to addressing the evolving requirements of young hockey players and their families, aiming to provide holistic solutions that extend beyond the surface needs.

3.1.3 Categorization of Needs

Category	Needs and Descriptions
Wishes	- Innovative training features that surpass traditional methods. - Integration of virtual reality for immersive training experiences. - Personalized training plans tailored to individual player strengths and weaknesses.
Wants	- User-friendly mobile app for tracking and analyzing performance. - Integration of gamification elements to enhance training engagement.
Latent Needs	- Social integration features to foster team bonding. - Real-time performance analytics for in-depth skill assessment. - Utilization of sustainable and eco-friendly materials in equipment design and manufacturing.
Immediate Needs	- Affordable training equipment accessible to a broad user demographic. - Development of durable, lightweight, and unobtrusive equipment designs prioritizing player safety and comfort. - Provision of clear and intuitive instructions for effective use of training equipment.

Table 4 – Categorization of Needs

3.3 Analysis – Human Factors

This section assesses measurements vital to the final design of the Elite Development Gear. Emphasizing human-centric considerations, this analysis incorporates previous research and an in-depth ergonomic study of human proportions. These specific dimensions will substantiate the design's practicality, especially for gear requiring adaptable features to cater to the varied physiques and movements of young hockey players.

3.3.1 Product Schematic – Configuration Diagram

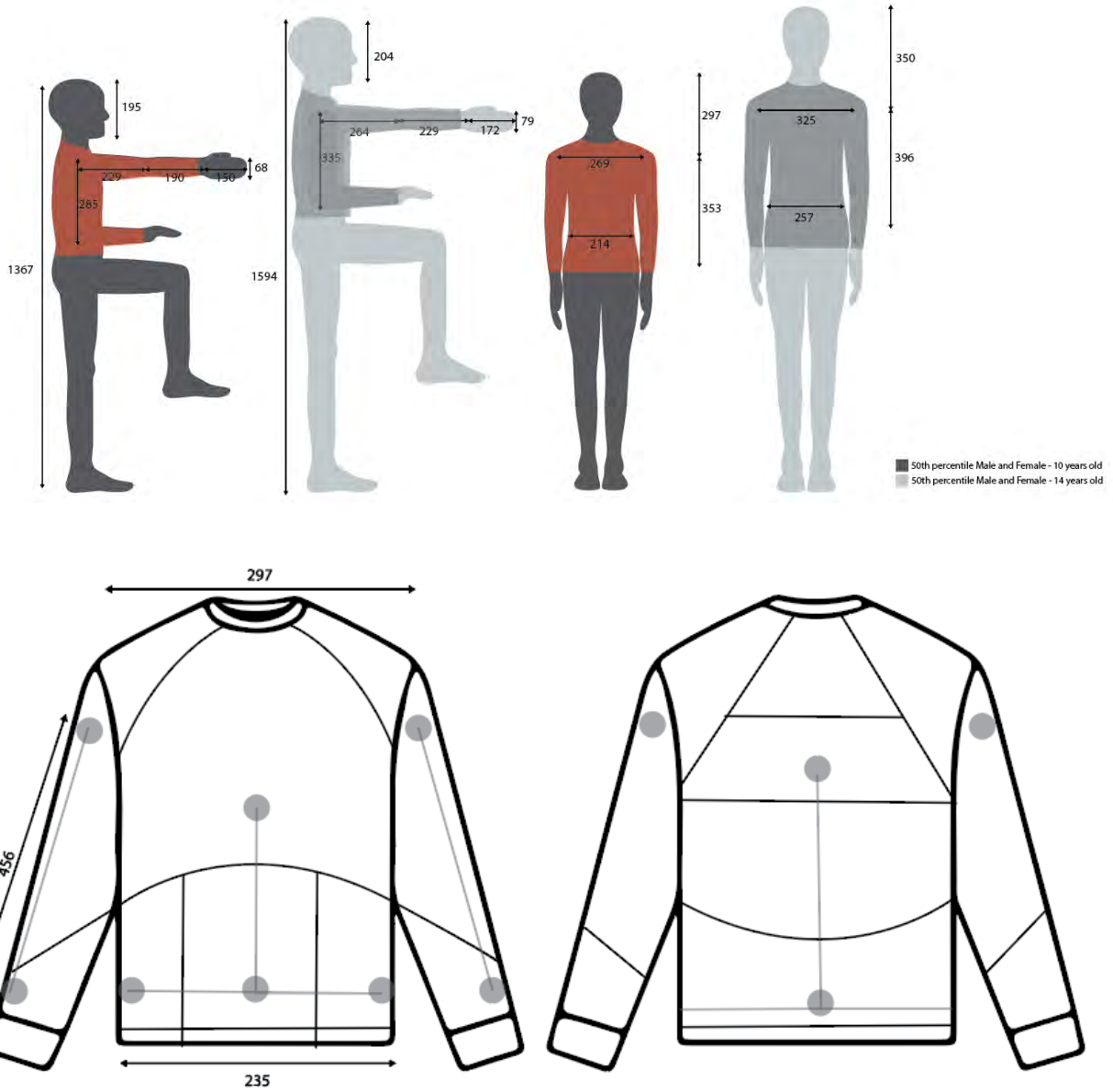


Figure 2 – Product Schematics for base layer shirt

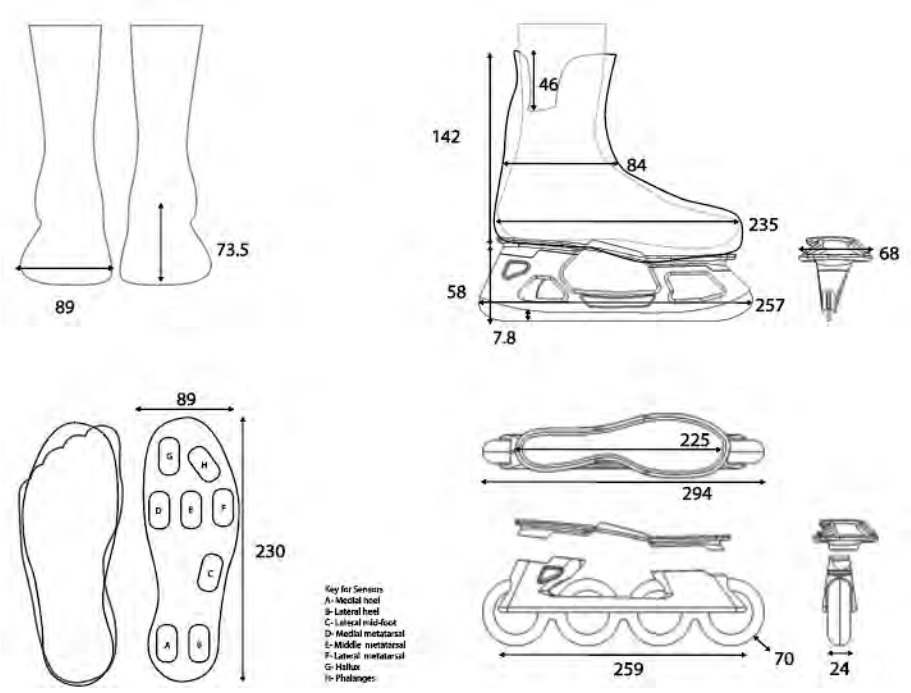


Figure 3– Product Schematics for skate and wheel holder

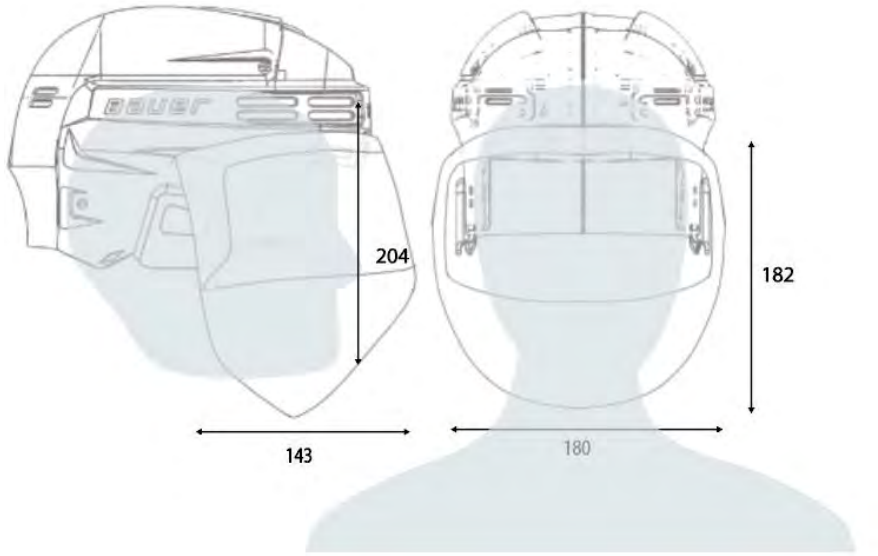


Figure 4– Product Schematics for face shield

The studies of Product Schematics are foundational to understanding how a product is structured and how its components interact. They provide a visual representation that highlights the relationships between different parts of a product, which is essential when integrating complex systems that must work together.

3.3.2 Ergonomic – 1:1 Human Scale Study

Figure 5- User standing upright with upper body sensor placement

Figure 6- User in hockey stance with upper body sensor placement

These diagrams help to conceptualize where sensors can be placed on the product to not impede user comfort or the product's functionality. By visualizing the configuration, designers can ensure that sensor placement aligns with the natural movements and contact points of the human body, thereby collecting more accurate data without sacrificing comfort.

Figure 7- User with hand interacting with skate holder mechanism

A comprehensive ergonomic analysis was conducted using full-scale to show the interaction between users and the product. As part of this analysis, an in-depth observation was undertaken, exploring major touchpoints, justifying the current design, and pinpointing any existing ergonomic challenges that warrant refinement.

The model was designed to meet the specific needs of the target demographic, with the blade holder capable of accommodating users at the 95th percentile for 14-year-olds. This design features a standard blade length of 254mm and a wheel holder aligned with the standard wheel size of 72mm.

The ergonomic exploration involved the utilization of a mockup to examine locations for motion sensors on the upper body. The user was examined in both a standing position and a hockey stance, which encapsulates the primary posture during active hockey engagement (Figure 1 and Figure 2). This foundational forward stance, also called the "ready" position, has the user with feet at shoulder width, flexed knees and ankles at approximately 45 degrees, a slight forward lean of the upper body with weight distributed on the balls of the feet, head looking forward and both hands holding the hockey stick which lies flat on the ice to the side of the body (Hockey Canada, 2018). Upper body sensor placement was designed to capture key elements such as posture, arm swing involving the torso, shoulders, and arms. Another key measurement for the product includes stride form which is detected through foot motion and pressure sensors at the sole of the foot. Additionally, users' hand interactions were examined, with a specific focus on their engagement with skate mechanisms.

Lastly in this study, the users' hands were examined for their interaction with the skate holder mechanisms (Figure 3). The user will change blade holder for wheel holder by pushing the buttons on either side of the holder simultaneously using a pinching motion to disengage. The second mechanism is used when the user will replace the skate blade by pulling back a trigger to release the blade. It is important that the user can comfortably and easily use these mechanisms.

3.4 Analysis – Aesthetics & Semantic Profile

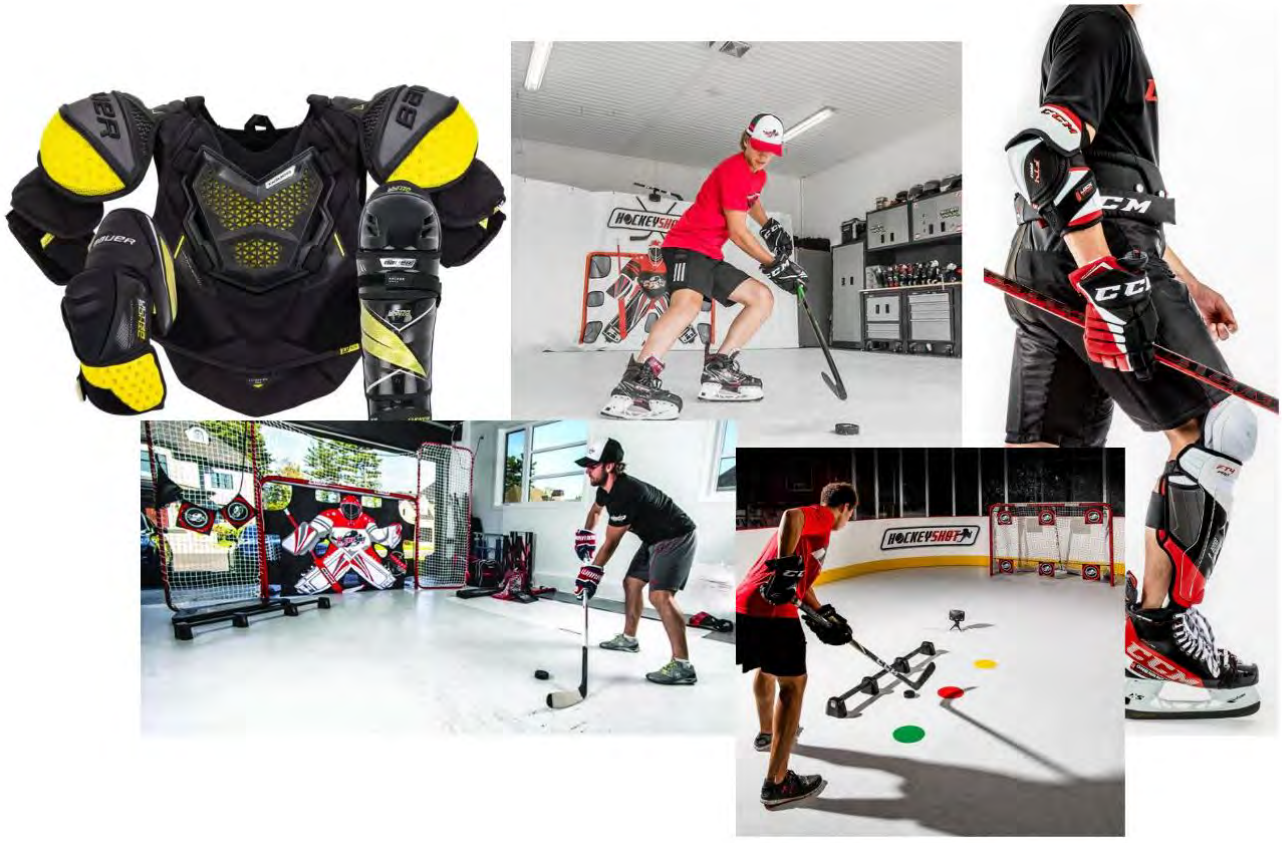


Figure 8 – Current sematic trends

Current aesthetic values and trends in hockey gear and training emphasize a sleek, high-performance, and technology-driven design. The predominant use of black and contrasting bright colors, such as red and yellow, conveys a sense of dynamism and energy. The integration of modern materials and clean lines points to a focus on advanced functionality and durability. Training equipment appears to be designed for precision and efficiency, with minimalistic yet impactful visual appeal. The gear is both robust and stylish, indicating that it's crafted to meet the needs of serious athletes who value both form and function.

3.5 Analysis – Sustainability: Safety, Health and Environment

The sustainability design approach for the Elite Development Gear (EDG) is defined by its commitment to the safety, health, and environmental impact of its products. The rationale behind selecting key differentiators in the design direction includes:

Safety: Materials and technologies are chosen for their non-toxicity, hypoallergenic properties, and compliance with rigorous sports safety standards to ensure athletes are protected during use.

Health: With a focus on the physiological well-being of the user, the EDG incorporates features like heart rate monitors and posture-tracking sensors to promote healthy training habits and prevent injury.

Environment: The selection of Tencel for apparel and recyclable engineering plastics for hardware reflects an intent to minimize environmental impact.

The business model supporting this sustainability design includes offering a long-lasting, adaptable product line that reduces the need for frequent replacements.

3.6 Analysis – Innovation Opportunity

3.6.1 Needs Analysis Diagram

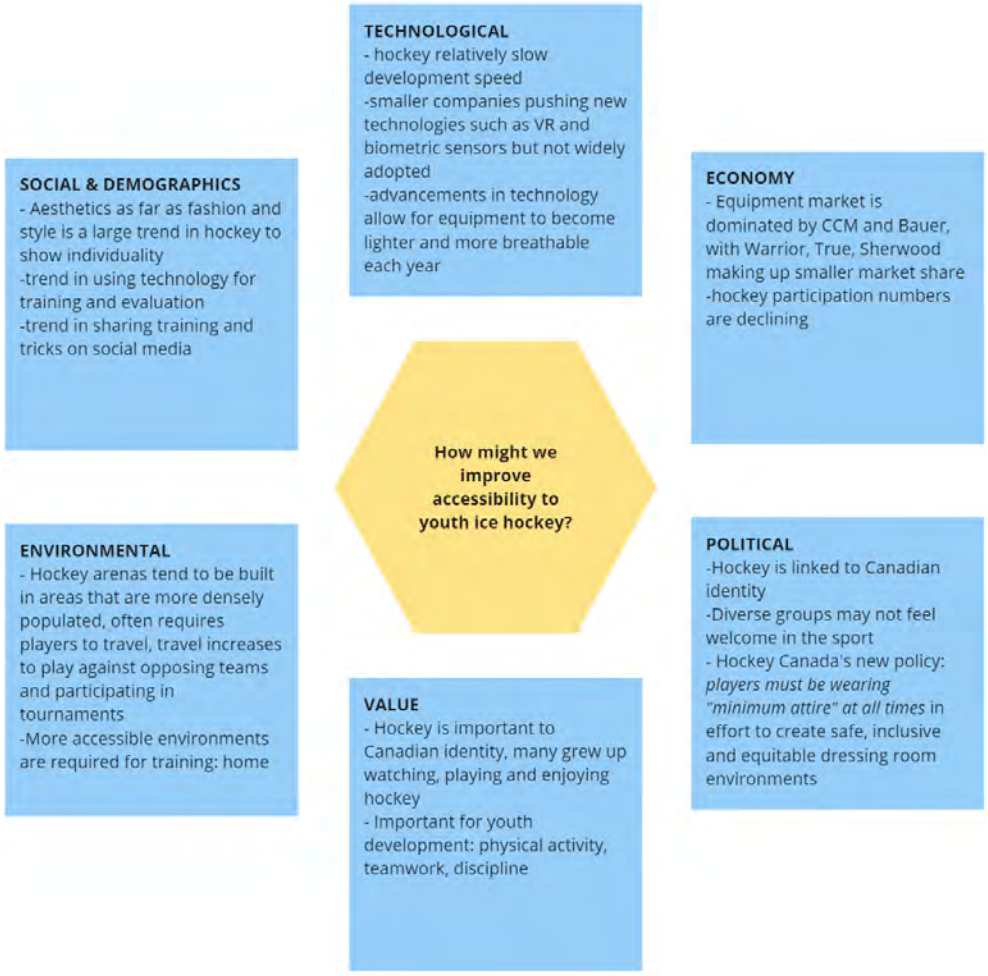


Figure 9 – STEEPV Analysis

3.6.2 Desirability, Feasibility & Viability

The project takes a user-centric approach, understanding the needs and desires of young hockey players, parents, coaches, and organizations through surveys, interviews, and observations. By creating detailed personas and conducting user research, it ensures that the proposed solution aligns with user expectations and preferences.

Feasibility is addressed through expert interviews, which provide insights into the financial and time commitments involved in hockey training. Additionally, benchmarking existing products helps in assessing the technical feasibility of incorporating similar functionalities into the proposed solution.

Viability considerations include understanding the financial barriers to accessing hockey and acknowledging the importance of sustainability in design and manufacturing. Market analysis helps in determining the potential demand for the proposed solution and its competitiveness in the market.

3.7 Summary of Chapter 3 – Defining Design Brief

This chapter begins by identifying gaps in the current market offerings based on insights gathered from Chapter Two's research. These insights are used to formulate needs statements that address the central thesis problem effectively. Several critical needs not met by current products are highlighted, including the necessity for affordable training solutions catering to diverse user demographics, the lack of innovative training features surpassing traditional methods, and the demand for real-time performance analytics. Additionally, latent needs such as social integration features and sustainability considerations emerge, reflecting a more comprehensive approach to addressing evolving requirements. Further analysis focuses on human factors, including ergonomic studies and product schematics, essential for understanding the practicality and interaction of the proposed gear with users. Aesthetic trends, sustainability considerations, and innovation opportunities are also explored to ensure the EDG aligns with modern design principles and market demands. Desirability, feasibility, and viability are key factors considered throughout the analysis, ensuring that the proposed solution not only meets user expectations but is also technically feasible, economically viable, and sustainable in the long run. This user-centric approach, combined with thorough research and analysis, lays a solid foundation for the development of the Elite Development Gear, aiming to enhance the training experience and performance of young hockey players while promoting safety, health, and environmental responsibility.

CHAPTER 4

DESIGN DEVELOPMENT

CHAPTER #4 – Design Development

4.1 Initial Idea Generation

This chapter explores initial ideas to the refinement of the final concept. This process encompasses a thorough examination of concept exploration, featuring product schematics and intricate design particulars. These stages collectively serve to inform the final design based on research conducted in preceding chapters.

4.1.1 Aesthetics Approach & Semantic Profile

Figure 10 – Mood Board

In terms of product semantics, the design embodies several key attributes. Symbolically, it conveys feelings of protection, durability, high-performance orientation, and dynamism. Aesthetically, the product

strikes a balance between robustness and streamlined form, exuding an aggressive, dynamic, and functional appearance while maintaining a sense of technical sophistication and lightweight design. Functionally, the product is geared towards providing protection, impact resistance, ergonomic comfort, flexibility to accommodate a wide range of motion, and adjustability. This presents an opportunity to offer solutions that not only align with the current market's expectations but also present a more approachable and less intimidating design. Moreover, the design prioritizes ease of use, ensuring that individuals can utilize it without requiring extensive prior knowledge.

4.1.2 Mind Mapping

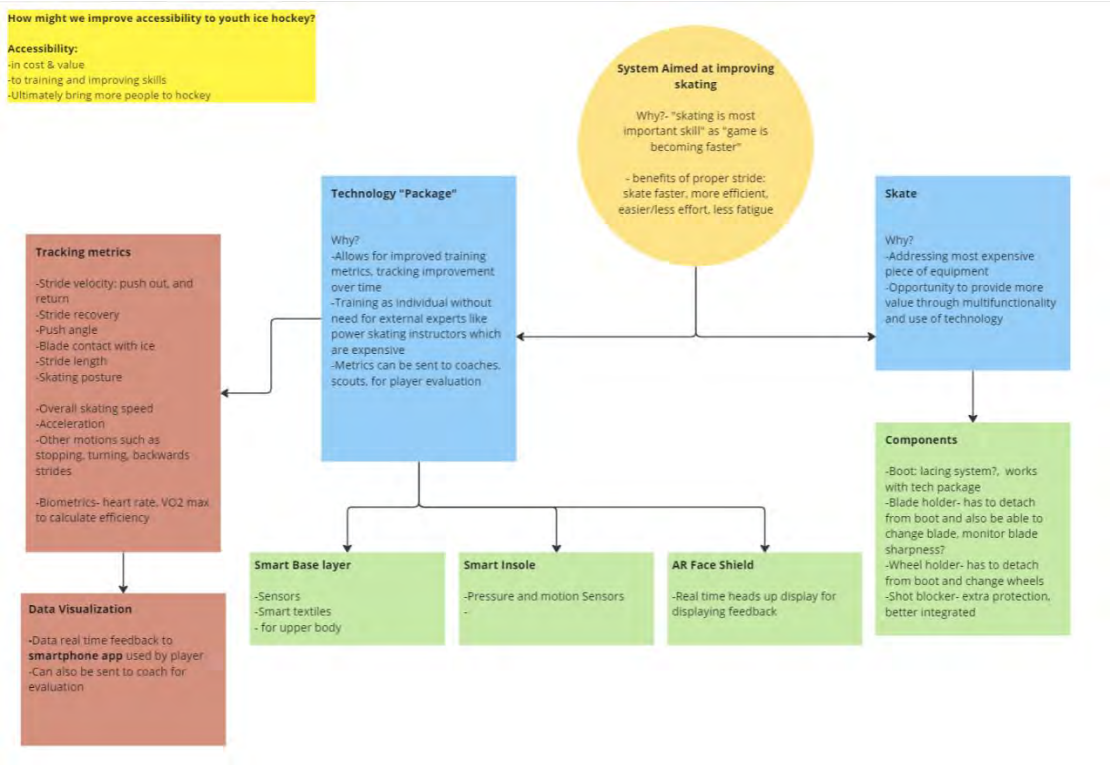


Figure 11- Mind Mapping

4.1.3 Ideation Sketches

The intent for initial concept ideation is to develop solutions that address financial barriers hindering youth participation in hockey. This includes tackling the high costs associated with equipment, training, league fees, ice time, and travel. The goal is to create products that make hockey more accessible, promoting a broader and more diverse demographic of participants while encouraging a healthier lifestyle and increased physical activity among youth. The needs encompass lowering costs and providing added value, while the wants involve creating comfortable, affordable, protective, user-friendly, and adjustable equipment, along with accessible training opportunities to bridge the high skill barrier in hockey. The product semantics aim for a design that conveys protection, durability, high performance, and dynamism while maintaining a robust, streamlined, functional, technical, and lightweight aesthetic. The functional aspects prioritize protection, impact resistance, ergonomics, flexibility, and adjustability. Overall, the goal is to offer solutions that align with the existing market while being more approachable, less intimidating, and user-friendly, even for those without prior knowledge.

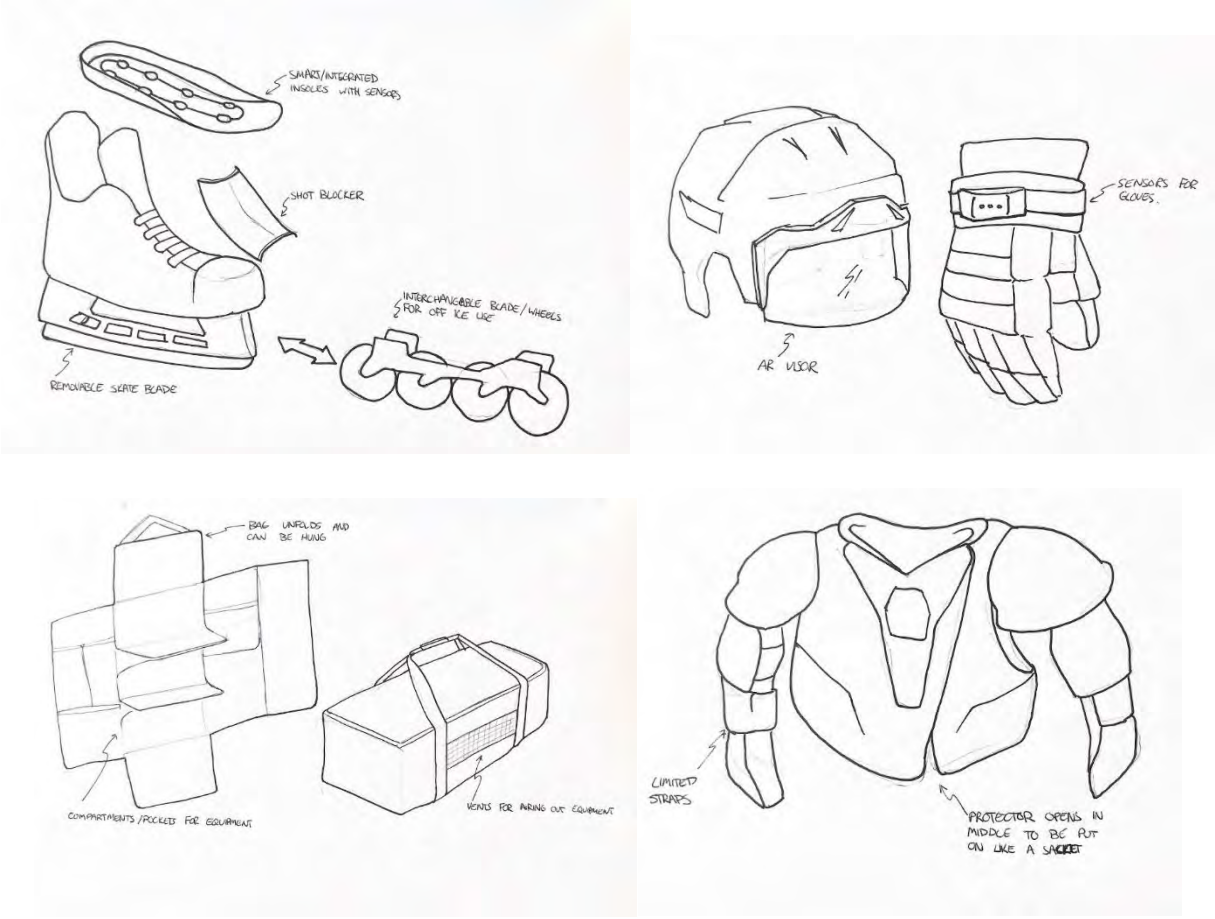
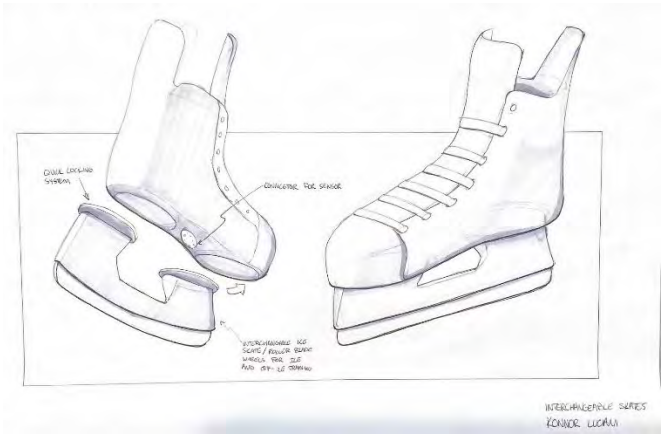


Figure 12- Initial Ideations

4.2 Concepts Exploration

4.2.1 Concept One – Interchangeable Skates



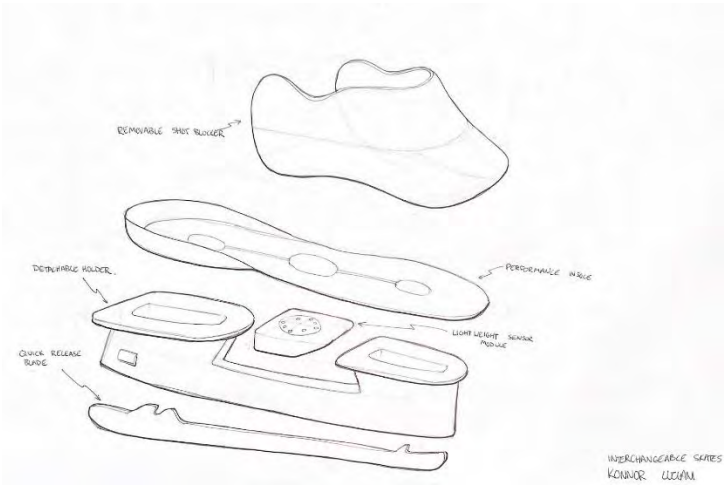


Figure 13- Concept 1 Interchangeable Skates

4.2.2 Concept Two

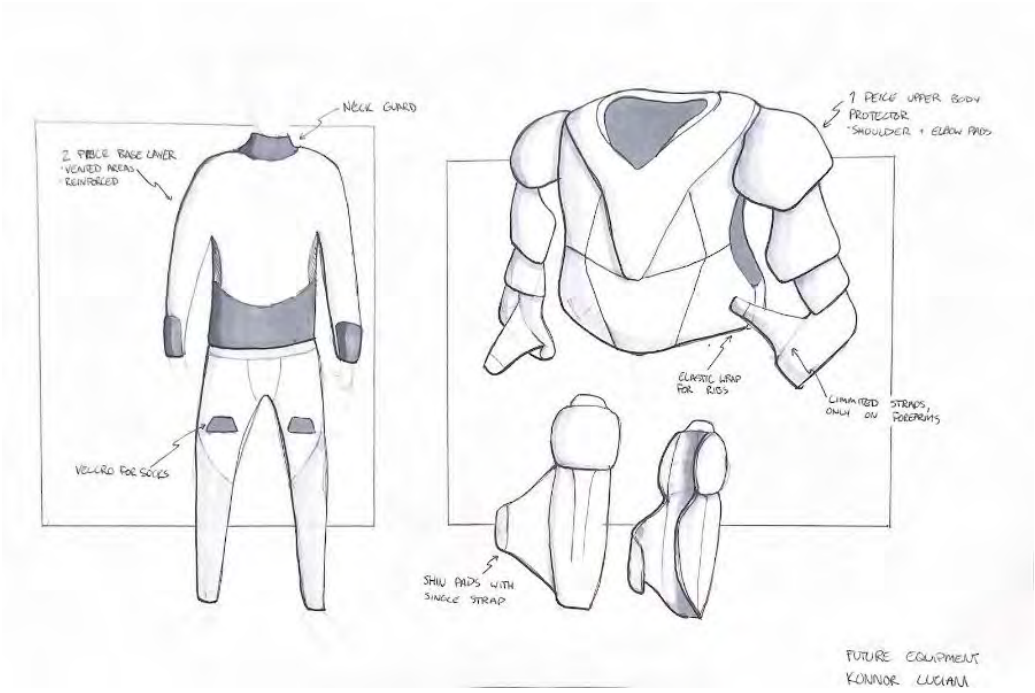
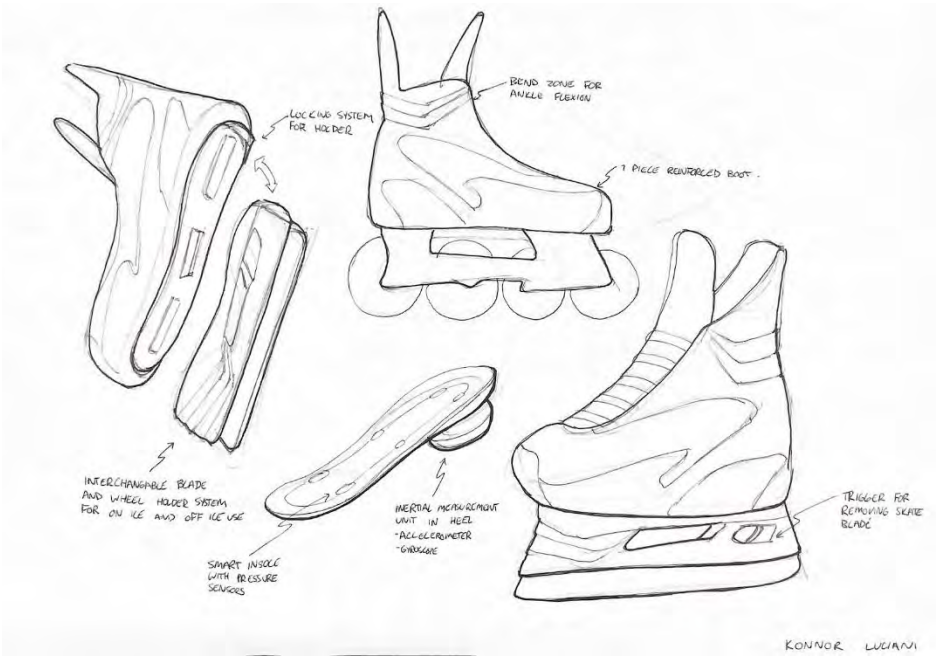


Figure 14- Concept 2 Future Equipment

4.3 Concepts Strategy

4.3.1 Concept Direction & Product Schematic One



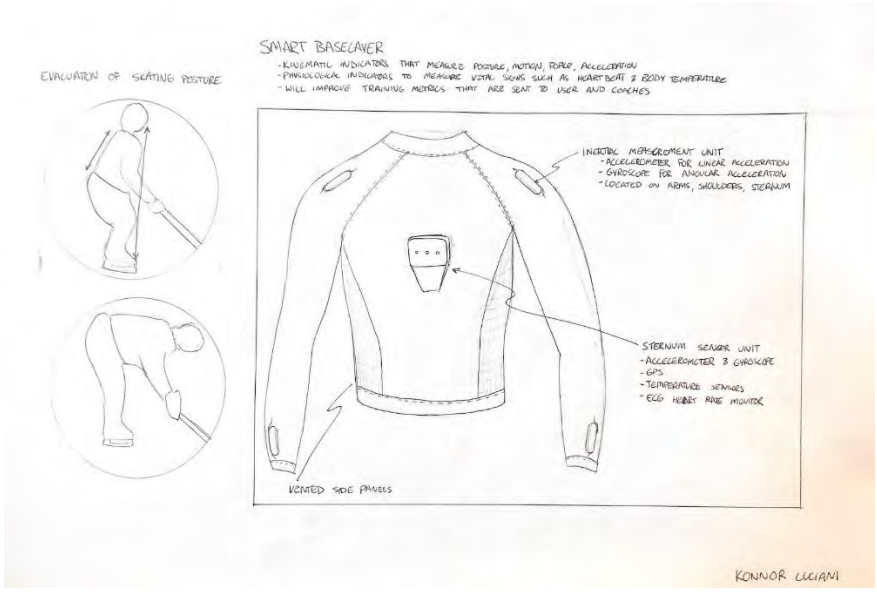


Figure 15- Refined Concept

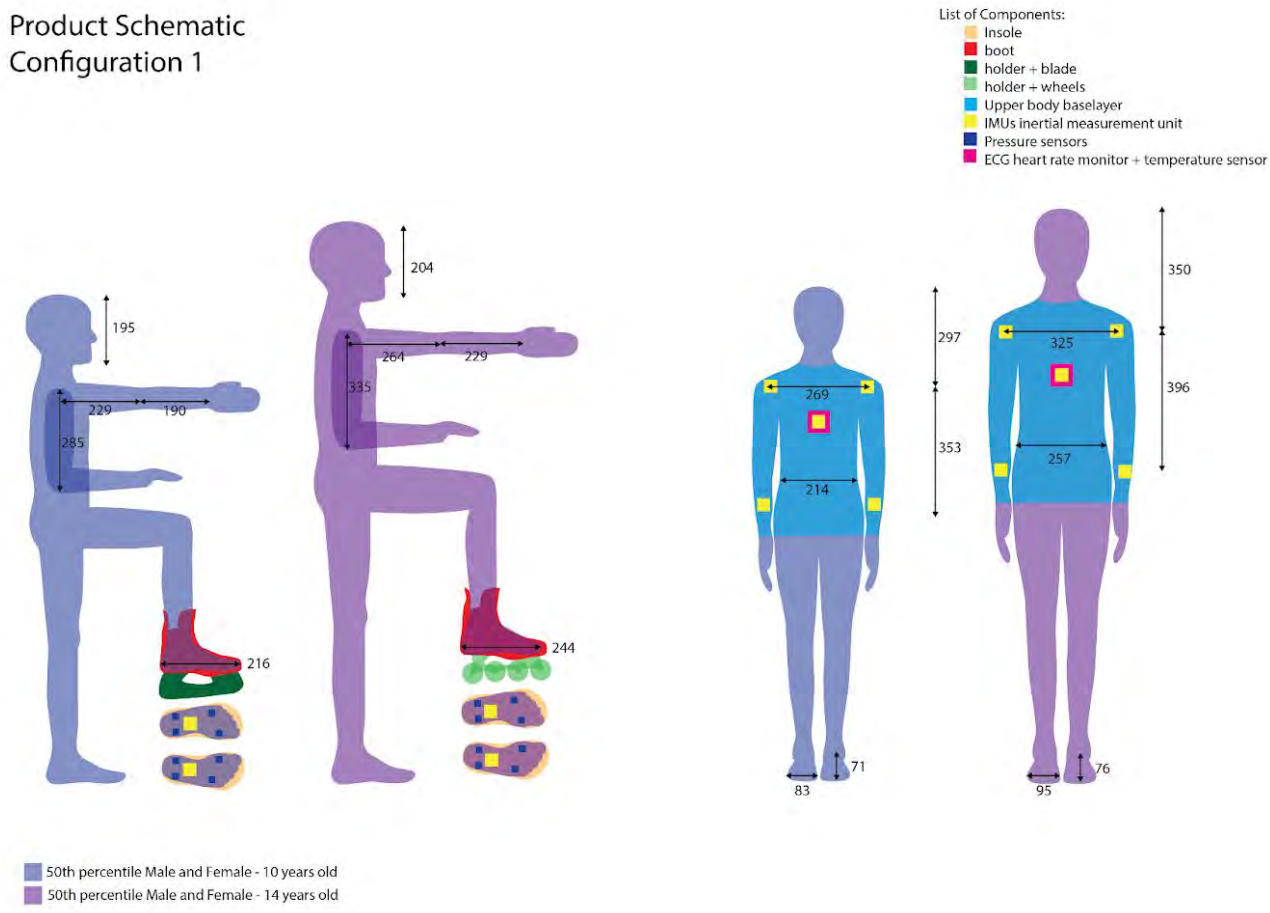


Figure 16- Concept 1 Initial Product Schematic

4.4 Concept Refinement & Validation

4.4.1 Design Refinement

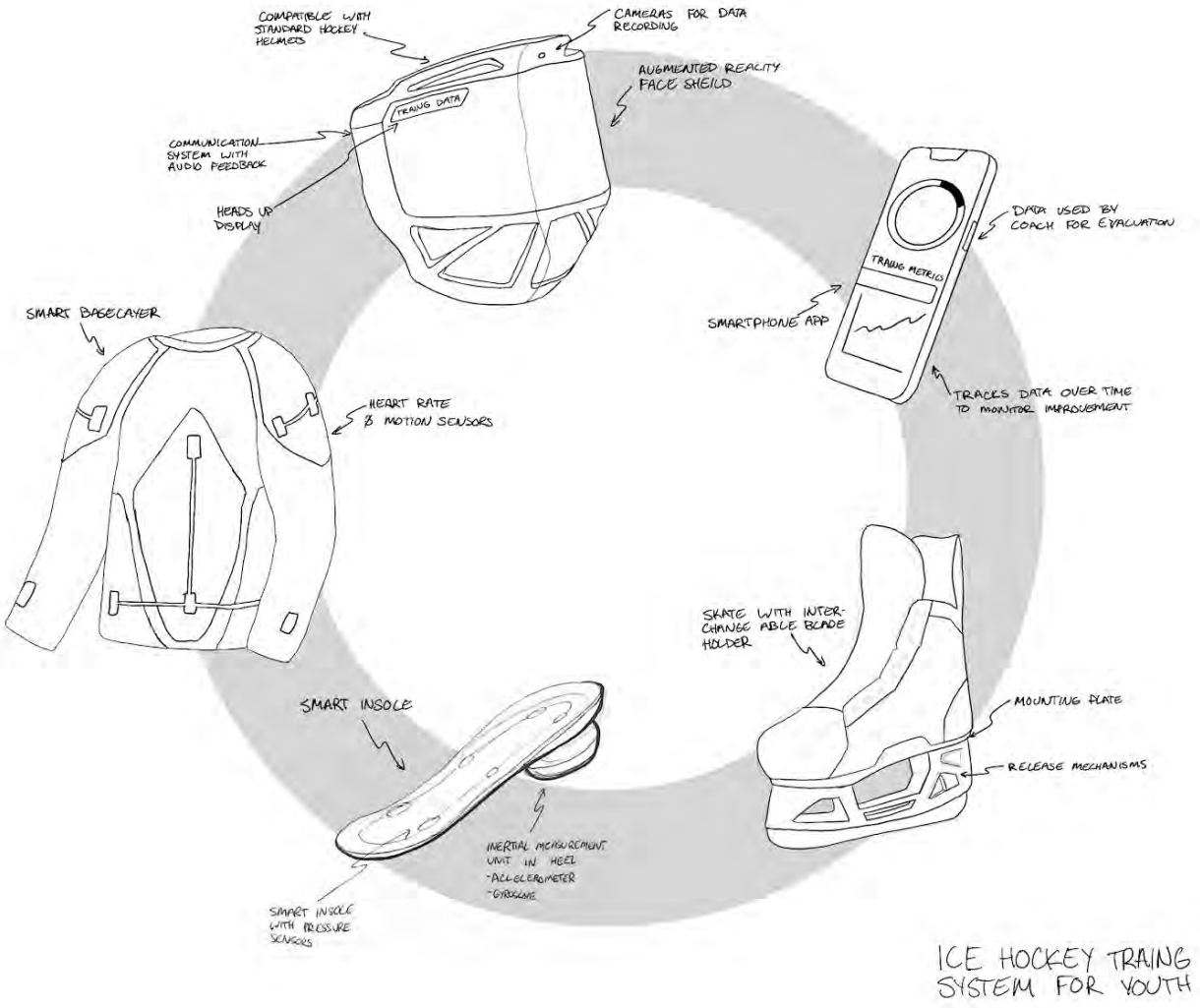


Figure 17- Concept Refinement

4.4.2 Design Development

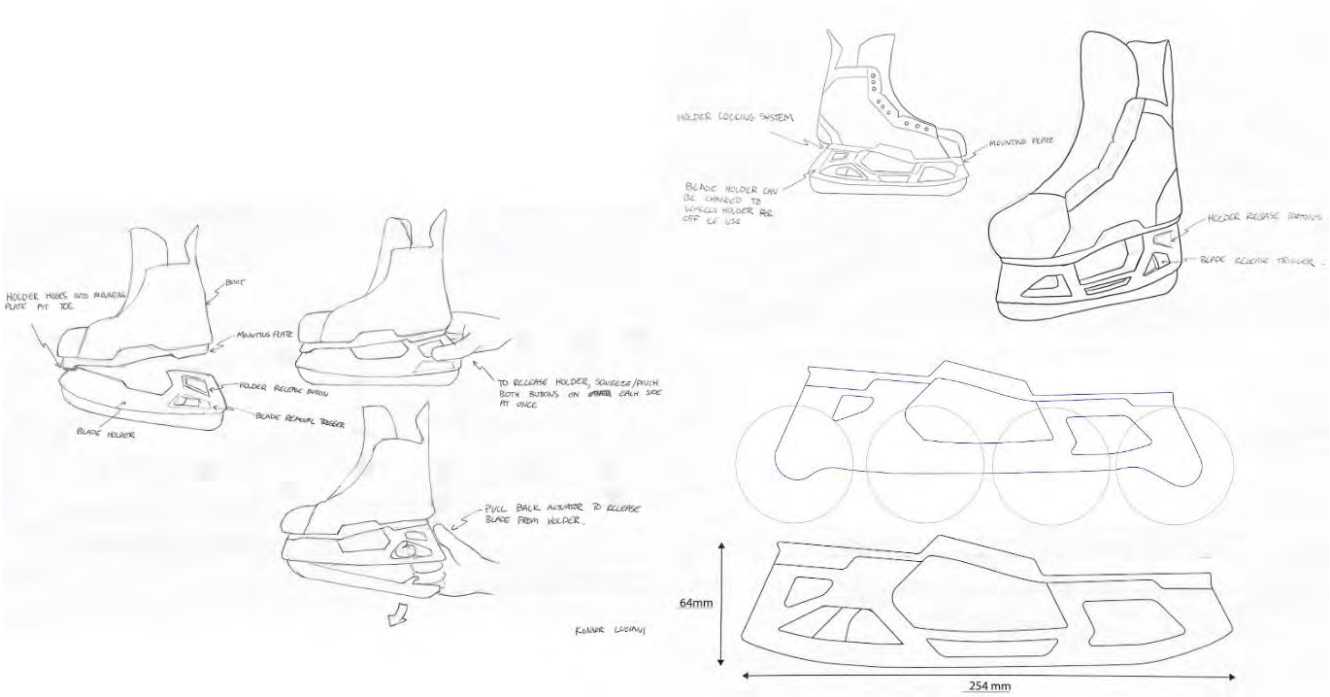


Figure 18- Design Development

4.4.3 Refined Product Schematic & Key Ergonomic

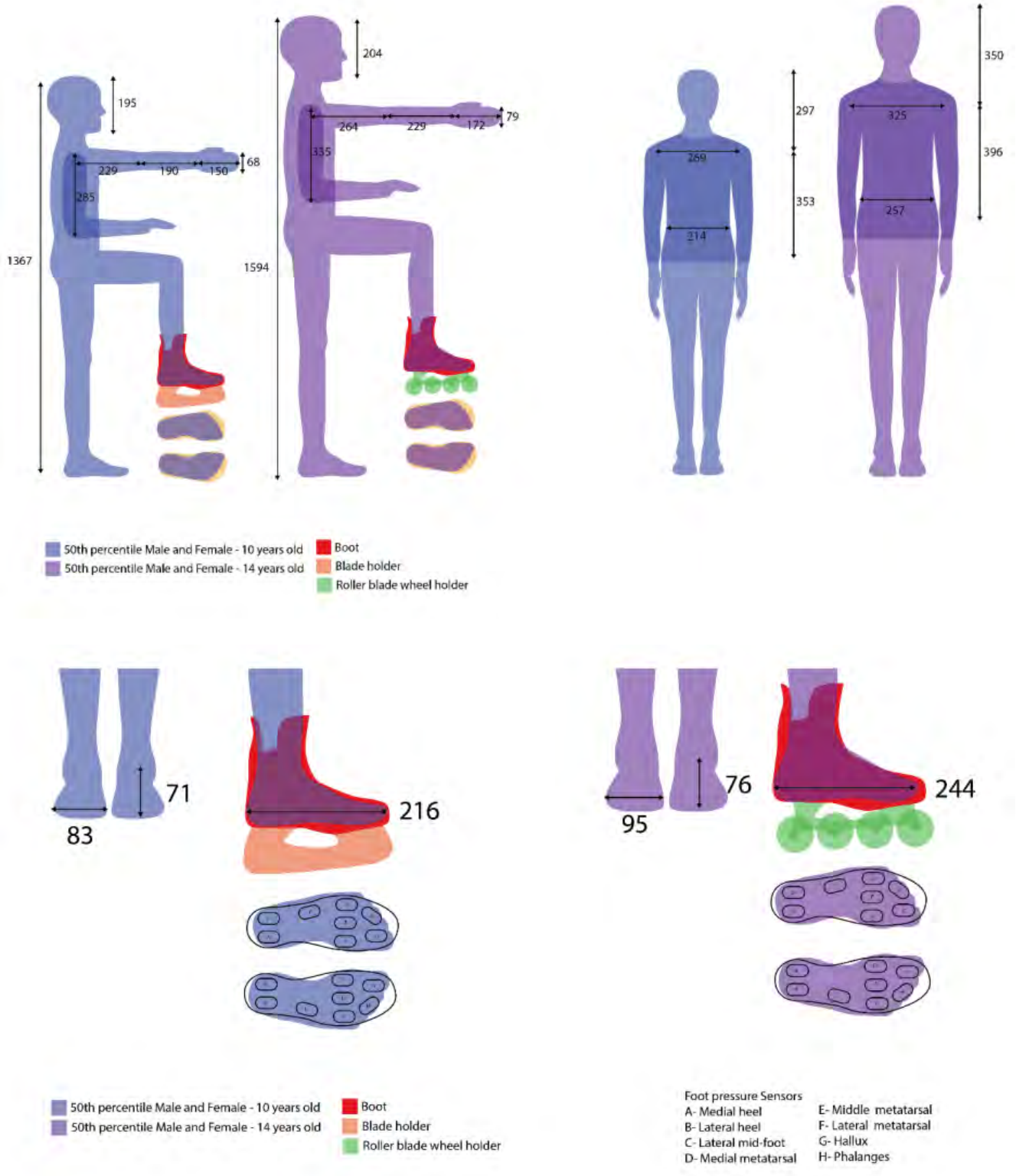


Figure 19- Refined Product Schematic

4.5 Concept Realization

Considering the insights gained from the initial concept, the final design has been refined to have a sleeker silhouette and a unified aesthetic that resonates across the entire product suite. While this new version preserves the essential attributes that defined the earlier model, it adopts a brighter and more engaging color palette, specifically chosen to captivate the younger demographic, ensuring that the design not only meets functional expectations but also resonates with its intended users on a visual and emotional level. Utilizing red in the design of this project is strategic, as it captures attention with its vibrancy, suggesting the energy and passion central to the spirit of the sport. Its motivational qualities can invigorate young players, while its high visibility ensures equipment is easily seen against the ice, enhancing safety. As a color that psychologically conveys confidence and power, it could positively influence a player's performance, making it not just a stylistic choice but a functional one that supports the project's goals of engagement and performance enhancement.

4.5.1 Design Finalization

The finalization of the design resulted in a family of designs to allow hockey players to train at an elite level, both on and off the ice, by integrating seamlessly with their existing gear. The product family includes an Augmented Reality face shield, a connected base layer shirt, a smart insole, and a hybrid skate holder. These products work together to provide a comprehensive training experience that addresses common challenges faced by players, including limited access to specialized training resources, restricted ice time, and the need to overcome a high skill barrier.

4.5.2 Physical Study Models

Physical prototypes were crafted to deepen our comprehension of the product's form before advancing its design within CAD software. Subsequent sections will display models of each element of the final design.

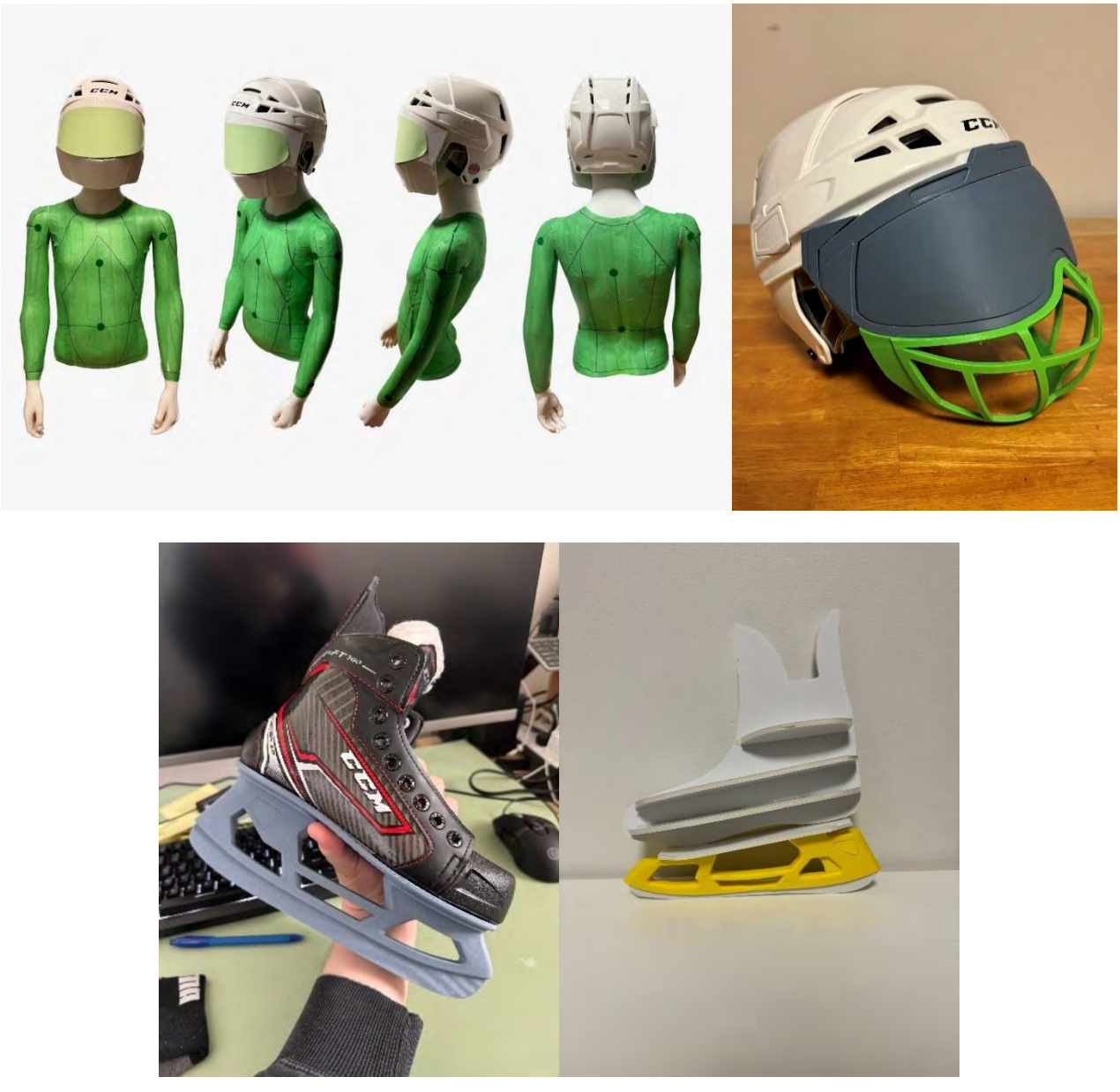


Figure 20- Earliest Physical Study Models

Figure 21- Physical Study Model iterations

4.6 Design Resolution

The Augmented Reality Face Shield is designed for hockey players to enhance their training, allowing them to complete drills on their own without the need for additional equipment or coaching. It features a digital lens that overlays real-time data and virtual scenarios directly onto the player's field of view, creating an immersive training experience. The shield is equipped with tracking sensors, including accelerometers, gyroscopes and depth cameras, to monitor the player's movements and responses accurately. A built-in microphone and touchpad facilitate user input, while a speaker integrated into the design provides auditory feedback, working in conjunction with the digital lens. Additionally, the face shield incorporates a side release mechanism for easy removal, enhancing convenience and comfort during intense training sessions.

The Connected Base layer Shirt is a garment designed to track motion and monitor physiological responses during training sessions. Embedding motion tracking sensors capture detailed data on the player's upper body motion and posture. A heart rate monitor provides insights into the player's performance and endurance.

The Smart Insole tracks movement patterns and skate dynamics to provide feedback on skating technique. Equipped with motion tracking sensors in the heel and pressure sensors in key areas along the sole, the insole delivers precise data on foot positional dynamics. It can distinguish between the inside and outside edge usage, allowing players to fine-tune their skating skills. By offering real-time feedback on footwork and balance, the Smart Insole is a valuable tool for players looking to improve their on-ice capabilities.

The Hybrid Skate Holder is designed to facilitate training both on and off the ice. The holder accommodates a blade for on-ice training and a wheel holder for off-ice sessions. With an easy-to-use holder release mechanism, players can quickly switch between blades and wheels, allowing for a seamless transition from ice to any flat surface. This flexibility enables players to train anywhere, anytime, significantly expanding the possibilities for skill development without the need for a rink.

4.7 CAD Development

Initial CAD models were created to conceptualize the final product's form and assembly methodology. The design was then refined, ensuring that the new products seamlessly interface with existing equipment. To achieve this precision, actual helmets and skates were 3D scanned and imported into SolidWorks to serve as accurate reference points. The majority of the modeling work was accomplished in SolidWorks, while the textile base layer shirt was made in CLO. For rendering and finishing, KeyShot was utilized to add realistic decals and materials.

Figure 22 – CAD Development for face shield including helmet 3D scan

Figure 23 – CAD Development for skate and wheel holder

Figure 24 – CAD Development for baselayer shirt

4.8 Physical Model Fabrication

The physical model was constructed from predominantly 3D printed components made of PLA, produced using a home FDM printer. Each part underwent a thorough process of sanding, followed by an application of Bondo and filler primer to achieve a smooth finish. Parts received a final layer of paint and were then assembled. For the transparent elements of the final design, such as the lens and lower face guard of the AR shield, production was outsourced to Objex Unlimited, where an SLA printer imparted a crystal-clear quality to these pieces. Existing hockey helmet and skates were disassembled and painted to show EDG connected and working with existing equipment. The shirt's pattern, designed in CLO, was cut and sewn by a professional seamstress. To complete the garment, vinyl decals were precision-cut and adhered using heat transfer, giving the piece a polished and durable branding.

Figure 24 – 3D printed parts

Figure 25 – Physical Model Fabrication

Figure 26 – Fabrication of base layer shirt

Figure 27 – Physical Model parts before assembly

CHAPTER 5

FINAL DEISGN

CHAPTER #5 – Final Design

5.1 Design Summary

The design journey for this kicked off with the generation of diverse concepts aimed at enhancing the training and performance of young hockey players, eventually synthesizing into a unified family of products. Key decisions were informed by an iterative process driven by the primary and secondary research findings, addressing both evident and underlying needs such as accessibility, usability, and the integration with existing hockey gear.

The result is Elite Development Gear, which comprises an interconnected family of products engineered to optimize on-ice and off-ice training. EDG is designed to confront the current challenges faced by young athletes, including the cost barriers to entry, the need for skill development outside traditional environments, and the physical demands of the sport. Elite Development Gear enhances the training experience by offering customizable solutions that adapt to various training scenarios and work in harmony with athletes' existing equipment, ensuring that progress and performance improvement are within every young player's reach.

5.2 Design Criteria Met

This section will examine how the Elite Development Gear adeptly fulfills the design criteria set out for this thesis project, encompassing full-bodied interaction design and aligning with all four foundational pillars. Additionally, this section will evaluate the design's practicality, considering the choice of materials and the manufacturing techniques employed.

5.2.1 Full Bodied Interaction Design

Elite Development Gear offers a unified family of products designed for full-bodied interaction, enhancing the training experience for young hockey players by engaging their entire body. This user-centric design is meticulously tailored to meet the ergonomic needs of young athletes, ensuring safety and comfort. Key features of the gear include adjustable components that cater to various body sizes, enhancing posture and movement. For example, the AR face shield adjusts to fit different head sizes and provides clear, unobstructed views for better situational awareness. Similarly, the connected baselayer shirt and smart insoles are made from adaptive materials that move with the body, offering real-time feedback and integrating seamlessly as a natural extension of the athlete. This approach addresses aspects of usability, comfort, and performance, allowing the gear to function cohesively to support the athletes' goals. The integration of these features into a single system underscores the project's commitment to full-bodied interaction design, significantly improving athletic performance and user engagement.

5.2.2 Materials, Processes and Technology

The Elite Development Gear utilizes a combination of advanced materials and manufacturing processes to optimize performance, safety, and comfort for young hockey players.

Advanced Textiles: The base layer shirt employs high-performance fabrics known for their elasticity, moisture-wicking properties, and breathability. These materials ensure that the shirt moves with the athlete, supports muscle performance, and remains comfortable under intense training conditions. Tencel (Lyocell), derived from sustainably sourced eucalyptus trees, is chosen for base layer shirt in the Elite Development Gear due to its eco-friendly production and superior properties. This advanced textile is produced using a closed-loop process that significantly minimizes environmental impact by recycling water and chemicals. Tencel excels in moisture management, keeping wearers dry during intense activities, and offers a soft,

irritation-free touch ideal for continuous wear. Additionally, its durability, breathability, and thermal regulation make it well-suited for sports apparel. Notably, Tencel is biodegradable, aligning with the project's sustainability objectives by ensuring the material does not contribute to landfill waste at the end of its lifecycle.

Injection Molding: Used for producing consistent, high-strength parts for the protective gear and skate holders. It facilitates the mass production of components featuring complex geometries and requiring substantial material durability, such as the outer casings of the smart insoles and the protective elements of the gear. Engineering plastics like Makrolon (Polycarbonate) and Bayblend (a blend of Polycarbonate and ABS) are chosen for their excellent mechanical properties, including robustness, durability, and impact resistance, which are crucial for withstanding the stresses, impacts, and low temperatures typical in hockey environments. Designing these components with durability in mind not only enhances their longevity but also contributes to the sustainability of the products.

Elite Development Gear incorporates a range of sophisticated technologies tailored to enhance training efficiency and athlete safety, making it a cutting-edge solution in sports gear. Key technological components include:

Fabric-Embedded Location Sensors: Integrated directly into the base layer shirt, these IMUs (Inertial Measurement Unit) measures and reports acceleration, orientation, angular rates, and other gravitational forces. IMU's track movement and posture in real-time, providing feedback that helps athletes optimize their form and technique during training sessions.

Heart Rate Monitor: Also embedded within the base layer shirt, the heart rate monitor tracks the athlete's cardiovascular performance, offering insights into their fitness level and intensity of exercise, allowing for training adjustments to maximize performance and safety.

Depth Cameras for Augmented Reality: Mounted on the AR face shield, depth cameras capture the spatial and depth information necessary for augmenting digital objects into the real world. This technology enhances training by providing interactive, real-time visual feedback and situational simulations that improve decision-making skills and cognitive reactions under varied game scenarios.

Augmented Reality Lens: The AR shield includes a high-quality, durable and protective transparent lens that displays data and images without obstructing vision, ensuring that athletes can view augmented reality overlays while maintaining unimpeded sight of their surroundings.

Pressure Sensors: Located in the smart insoles, these sensors measure the distribution of pressure throughout the foot during movement. This data is crucial for analyzing stride, balance, and technique, which can help in preventing injuries and improving performance metrics such as speed and agility.

All these devices — sensors, cameras, and monitors — are interconnected using Bluetooth technology. This setup allows for seamless communication between each component, ensuring that data collected is synchronized and processed in real-time to provide actionable insights directly to the athlete’s wearable display or a connected mobile device. Complementing the hardware, this system is equipped with advanced software that analyzes the data collected from all sensors and cameras. It provides athletes and coaches with detailed reports and feedback, which can be used to tailor training programs, monitor progress, and make data-driven decisions to enhance performance.

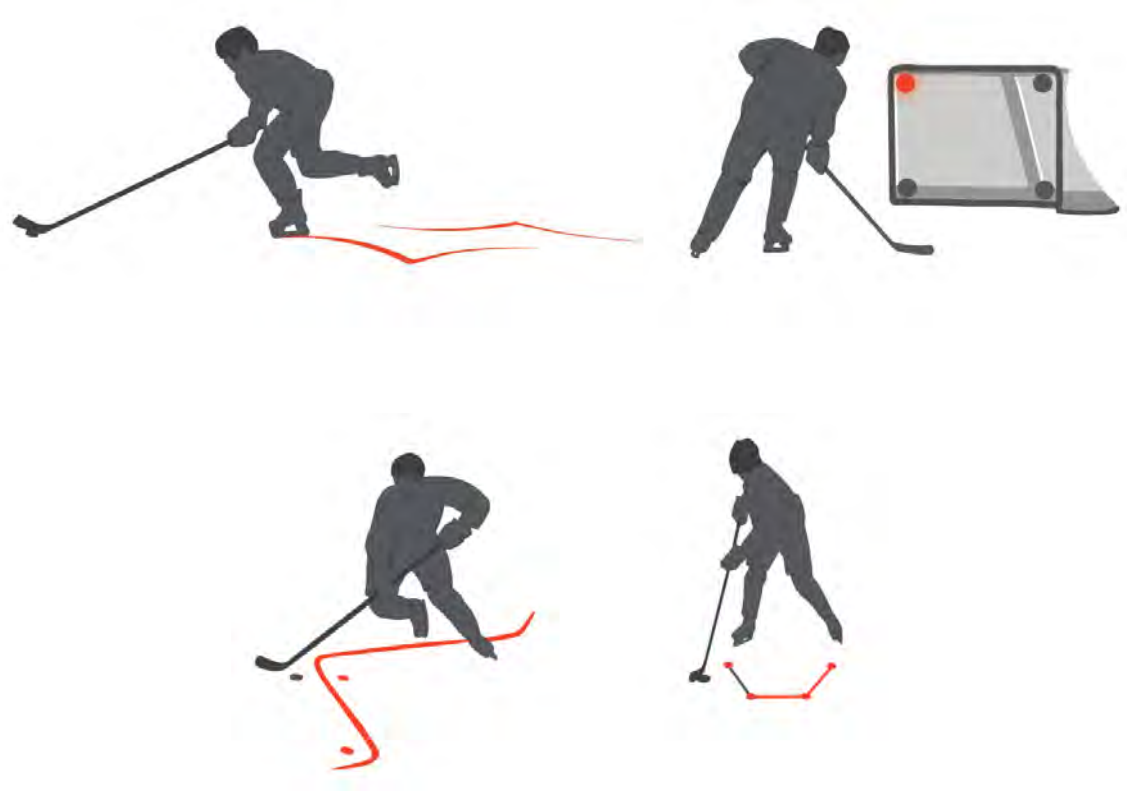


Figure 28 – Virtual projections for AR face shield. Includes stride technique, shooting, skating and stick handling.

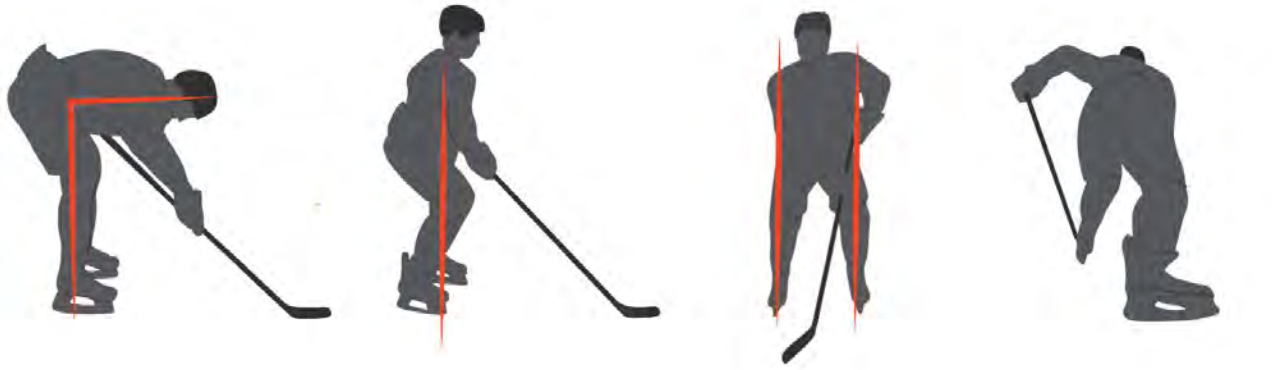


Figure 29 – Skating Mechanics. High-caliber skaters are differentiated by their effective skating mechanics, which include greater ankle motion, knee extension, and quick stride recovery. Skating efficiency, such as stride length and skating range of motion, may be more indicative of skating proficiency than speed and frequency of strides.

5.2.3 Design Implementation

AR Face Shield				
Part Number	**Name**	**Material**	**Manufacturing Process**	**Quantity**
A1	Lens	Polycarbonate	Injection Molding	1
A2	Display Interface (HUD)	LCD Display	Electronics Assembly	1
A3	Lower shield	Polycarbonate	Injection Molding	1
A4	Frame	Polycarbonate	Injection Molding	1
A5	Front Hinge	Polycarbonate	Injection Molding	1
A6	Side Bracket	Polycarbonate	Injection Molding	2
A7	Depth Cameras	Mixed Electronics	Electronics Assembly	2
A8	Electronics Housing	ABS Plastic	Injection Molding	1
A9	Microphone	Mixed Electronics	Electronics Assembly	1
A10	Speaker	Mixed Electronics	Electronics Assembly	2
A11	Bluetooth Module	Mixed Electronics	Electronics Assembly	1
A12	Power Supply (Battery)	Lithium Polymer Battery	Electronics Assembly	1
A13	Touch Sensor	Mixed Electronics	Electronics Assembly	2

Table 5 – Bill of materials for face shield

Base layer Shirt				
Part Number	**Name**	**Material**	**Manufacturing Process**	**Quantity**
B1	Base fabric- red	Tencel (Lyocell)	Textile Weaving	0.6 yd
B2	Base fabric- orange	Tencel (Lyocell)	Textile Weaving	0.6 yd
B3	Embedded IMUs (Location Sensors)	Mixed Electronics	Electronics Assembly	12
B4	Power Supply (Battery)	Lithium Polymer Battery	Electronics Assembly	1

Table 6 – Bill of materials for base layer shirt

Smart Insole x2				
Part Number	**Name**	**Material**	**Manufacturing Process**	**Quantity**
C1	Base fabric- red	Tencel (Lyocell)	Textile Weaving	0.1 yd
C2	Padding layer	Polyurethane foam	Foam Fabrication	0.1 yd
C3	IMUs (Location Sensors)	Mixed Electronics	Electronics Assembly	1
C4	Power Supply (Battery)	Lithium Polymer Battery	Electronics Assembly	1
C5	Pressure Sensors	Various Electronics	Electronics Assembly	8
C6	Flexible support shell	Thermoplastic polyurethane (TPU)	Injection Molding	1

Table 7 – Bill of materials for smart insole

Hybrid skate holder x 2				
Part Number	**Name**	**Material**	**Manufacturing Process**	**Quantity**
D1	Mounting Plate	Bayblend (Blend of Polycarbonate and ABS)	Injection Molding	1
D2	Blade holder	Makrolon (Polycarbonate)	Injection Molding and Assembly	1
D3	Roller wheel holder	Makrolon (Polycarbonate)	Injection Molding and Assembly	1
D4	Locking Mechanism	Bayblend	CNC Machining	1
D5	Quick-Release Button	Texin (Thermoplastic Polyurethane)	Injection Molding	2
D6	Adjustment Locking Screws	Steel	Cold Forming and Threading	2

Table 8 – Bill of materials for Hybrid skate holder

5.3 Final CAD Rendering

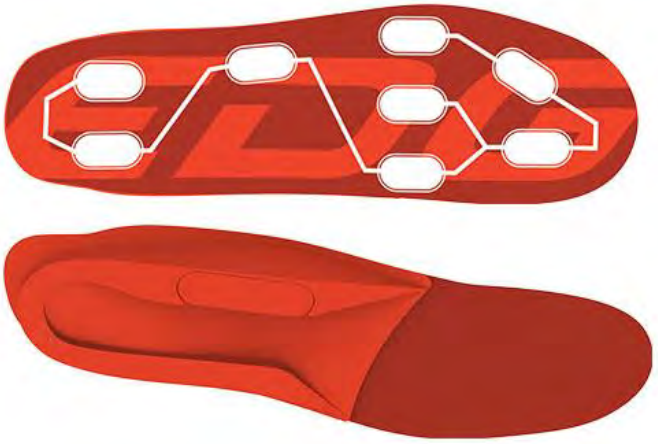

EDG
CM

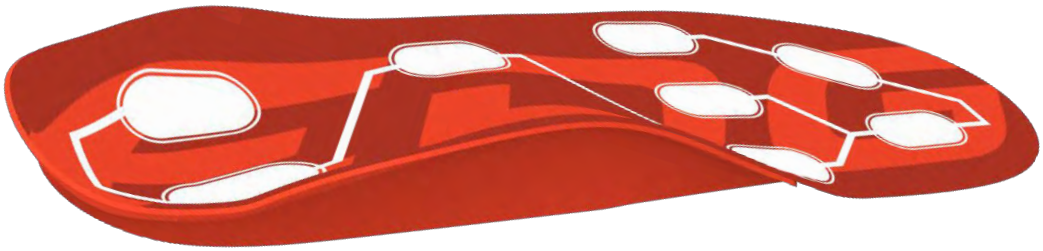

42
AVG. SPEED
16
AVG. HEART RATE
132


PUCK CONTROL


42
AVG. SPEED
16
AVG. HEART RATE
132
PUCK CONTROL


EDG
EDG





Product visualization for Elite Development Gear. Final renders include licensed 3D designed by external creators, used under permission: 3D model of Skates by Philogix Studio, 3D model of Helmet by Paramatma.

5.4 Physical Model

Figure 30 – Physical Model

Figure 31 – Physical Model

Figure 32 – Physical Model

5.5 Technical Drawings

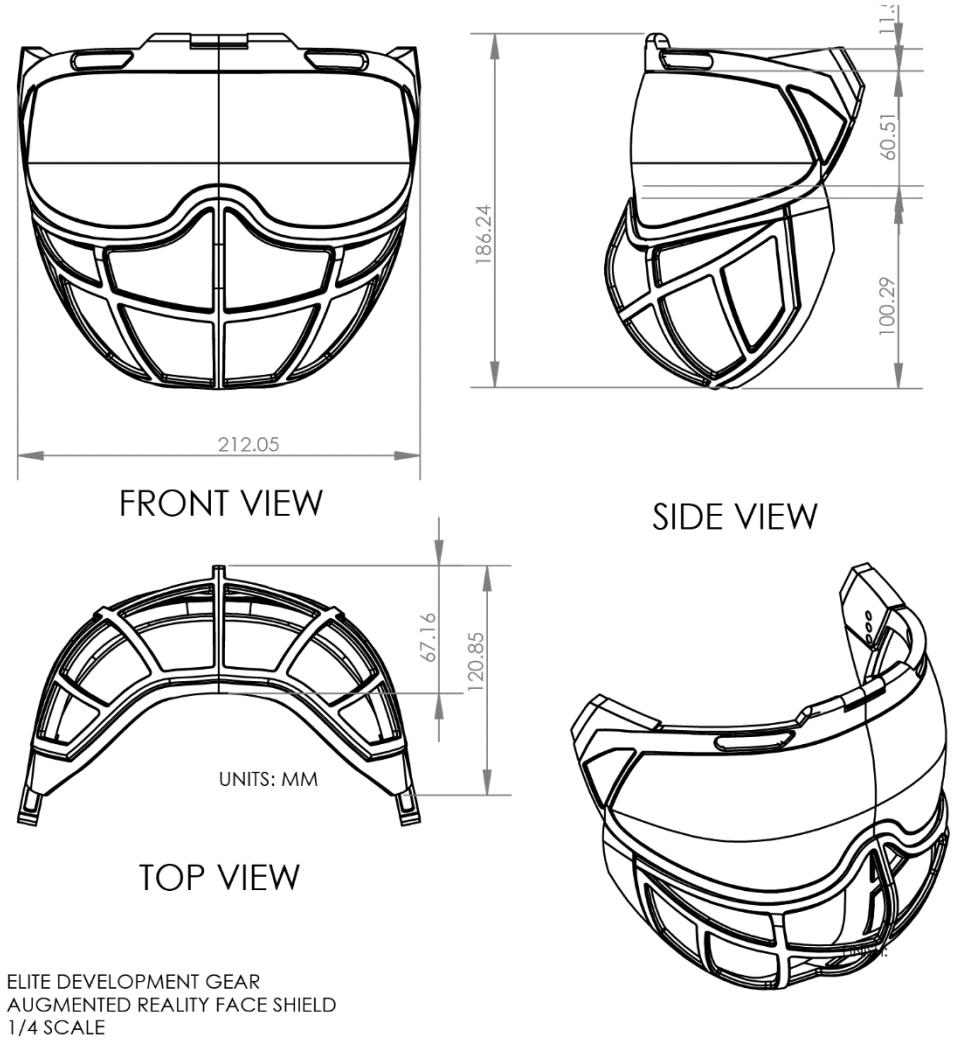


Figure 33 – Technical Drawing for AR face shield

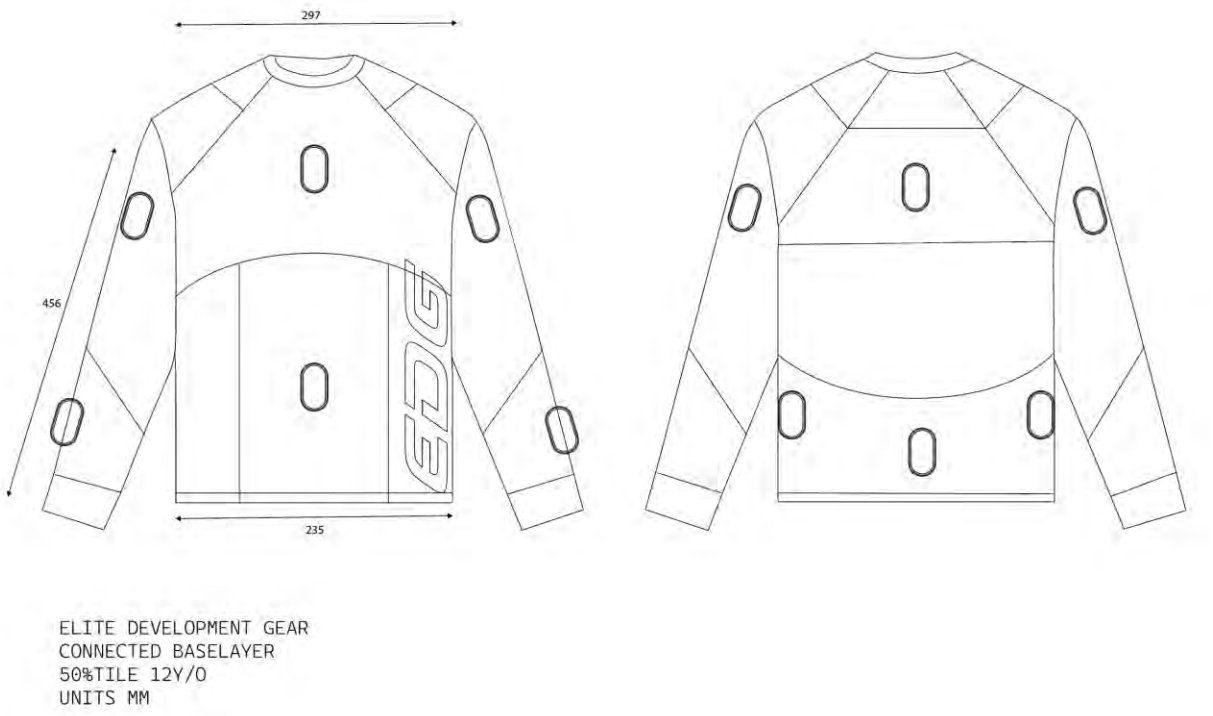


Figure 34 – Technical Drawing for connected base layer

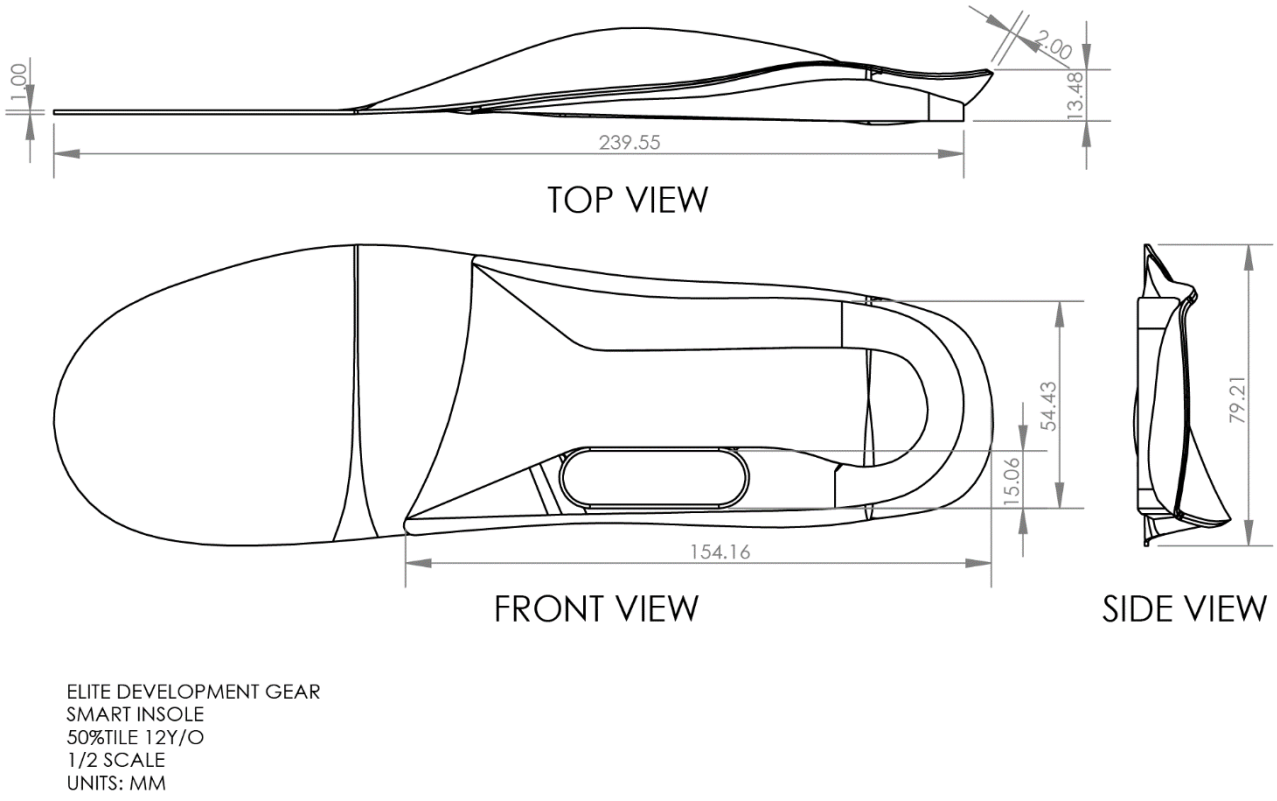
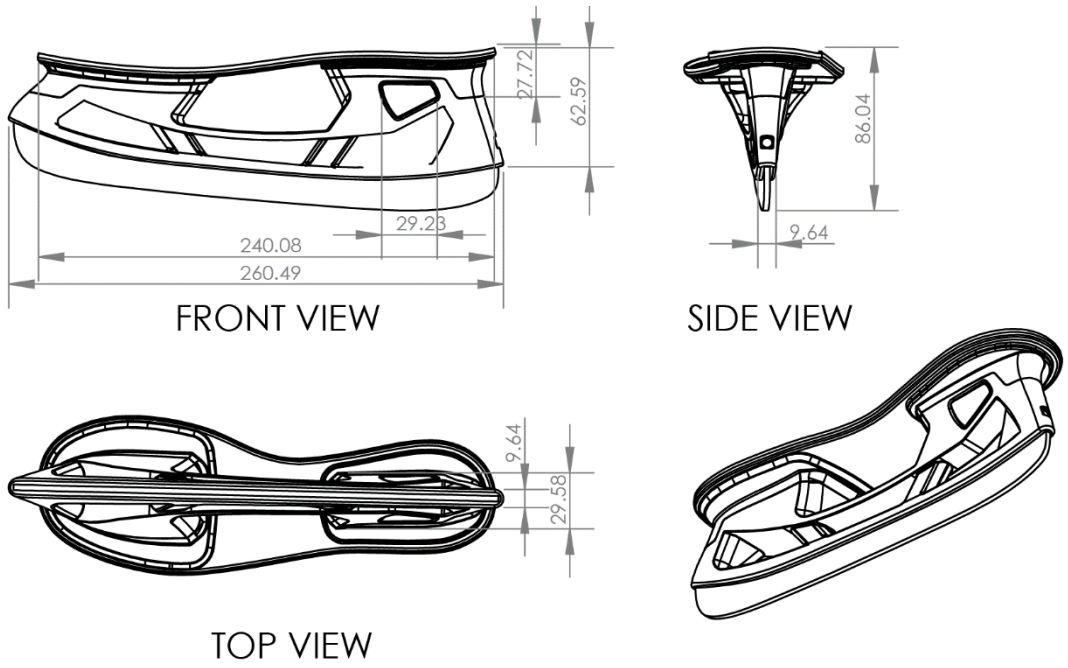
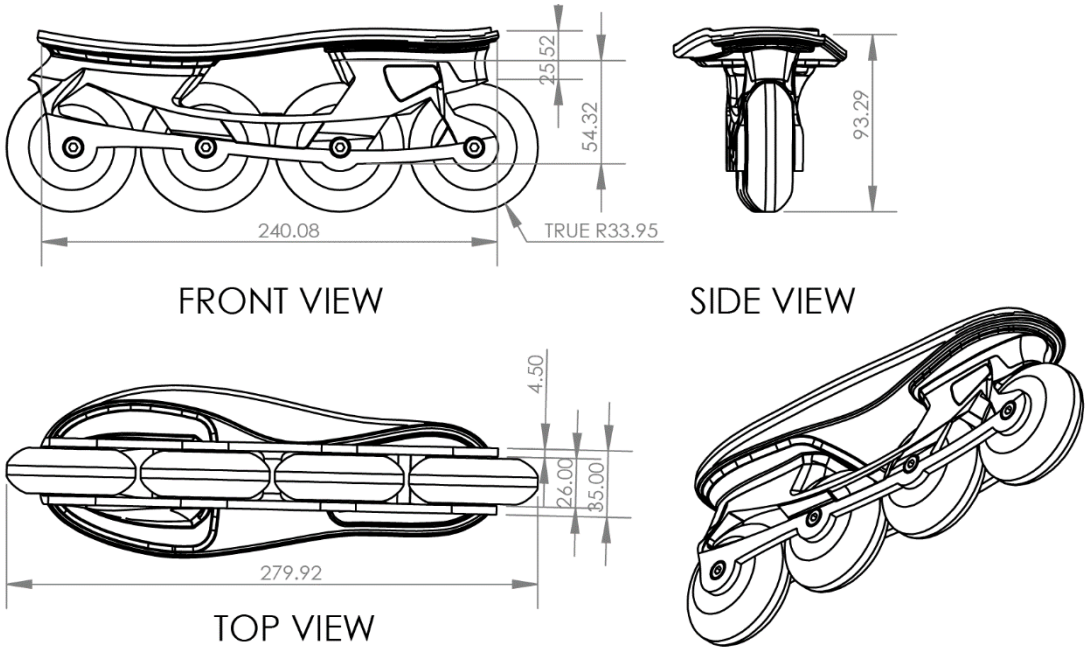


Figure 35 – Technical Drawing for smart insole



ELITE DEVELOPMENT GEAR
HYBRID SKATE HOLDER- BLADE
50%TILE 12Y/O
SCALE 1:4
UNITS: MM



ELITE DEVELOPMENT GEAR
HYBRID SKATE HOLDER- ROLLER
50%TILE 12Y/O
SCALE 1:4
UNITS: MM

Figure 36 – Technical Drawing for Hybrid skate holder: blade and roller

5.6 Sustainability

Elite Development Gear offers a more sustainable approach to hockey training. By designing gear that is effective for both on-ice and off-ice training, EDG significantly extends the usability and life span of the equipment, providing greater value and reducing the need for frequent replacements. This longevity not only reduces waste and the environmental impact associated with the production of new gear but also diminishes the resource consumption tied to the manufacturing process. Additionally, the EDG's ability to seamlessly integrate with existing hockey equipment enhances its accessibility and convenience for users. This compatibility ensures that players can adapt to new technologies without the need to entirely replace their current setups, further reducing material waste and the carbon footprint associated with acquiring new equipment. Moreover, by facilitating off-ice training capabilities, the gear minimizes the necessity for athletes to travel to rinks, thereby lowering travel-related carbon emissions and promoting a more eco-friendly training routine. Overall, the EDG project not only focuses on enhancing the performance and training efficiency of hockey players but also strongly considers the environmental impact of sports equipment.

Chapter 5 Conclusion

Elite Development Gear (EDG) is a holistic product suite that addresses the multi-faceted needs of young hockey players. Through a meticulous design process informed by comprehensive research, EDG has been engineered to enhance both on-ice and off-ice training, making high-level hockey training more accessible and effective. The integration of advanced textiles, smart technologies, and eco-friendly materials not only elevates the performance and safety of young athletes but also underscores a commitment to sustainability. This project's focus on user-centric, adaptable designs allows for a seamless integration with existing equipment, reducing environmental impact and fostering a sustainable approach to sports training. Ultimately, EDG represents a significant advancement in sports gear, offering innovative solutions that ensure young hockey players can achieve their highest potential while promoting a sustainable future for sports equipment.

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Appendix A – DISCOVERY

FTA-1 (B) – TOP 2 THESIS TOPICS SELECTION

Konnor Luciani

Topic 1

a) Research Question

How might we improve accessibility to ice hockey for youth?

b) Product Category & Possible Project Title or Name

Product category is recreation and sports. Possible tile is: Improving access to ice hockey.

c) Briefly explain what you know about this topic

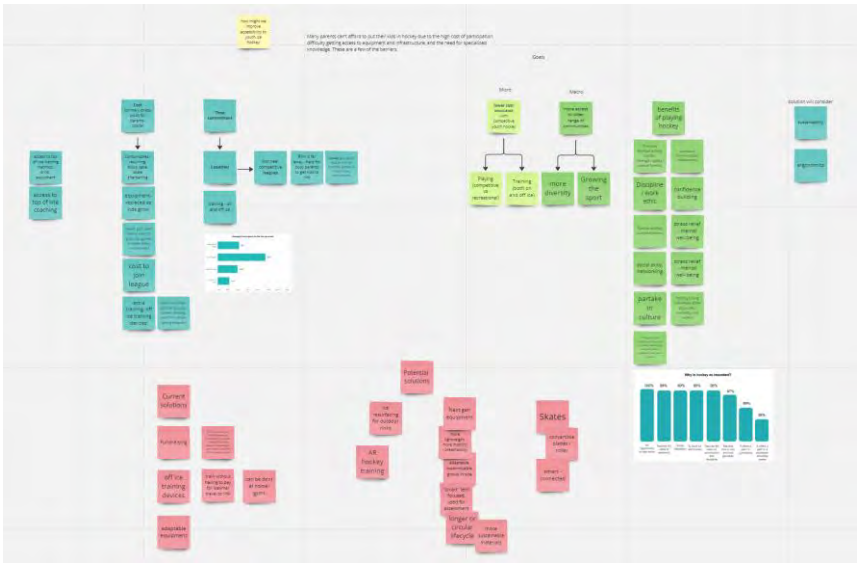
Access to hockey is often hindered by the high costs associated with equipment, training, and league fees including ice time and travel. Essential gear like skates and sticks can be expensive, and advanced levels of play require substantial financial commitments. Canadian families, on average, spend $1,700 yearly on hockey-related expenses. Aiming to lower costs will make the sport accessible to a wider range of communities, thus promoting physical activity. Additionally, it acknowledges the need to redesign hockey equipment to be lighter, more breathable, and sustainable, aligning with the growing consumer demand for eco-friendly products.

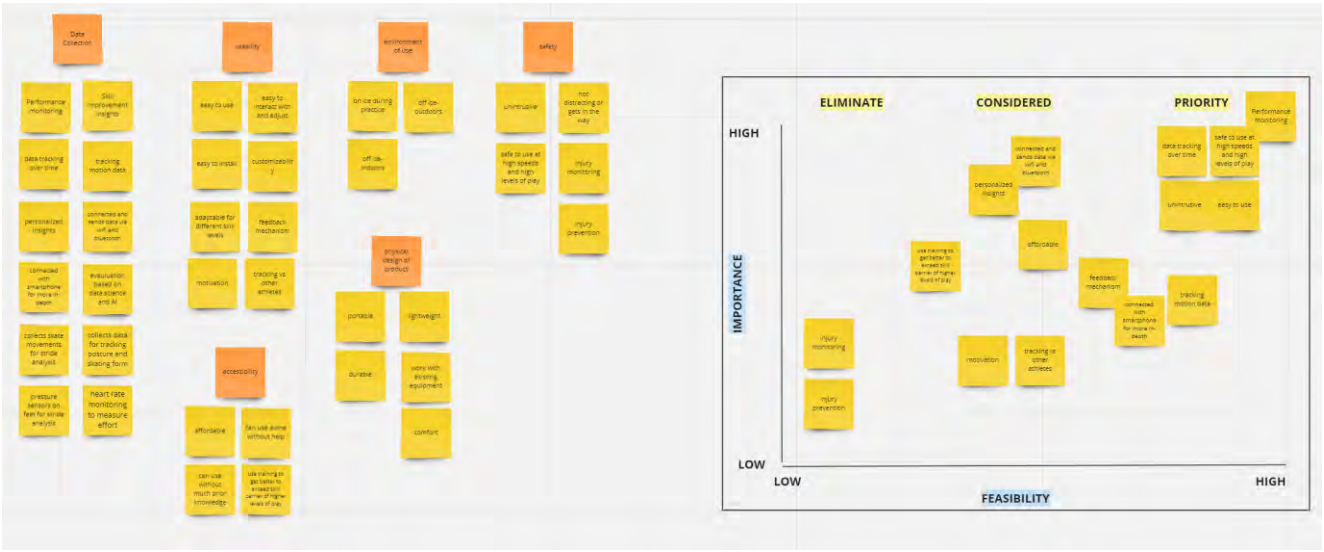
d) Why did you choose this topic as one of the top two?

I chose this topic as one of the top two due to personal interest and experience. Having played hockey for most of my life was a significant part of my upbringing. I am passionate about ensuring that everyone, regardless of their financial circumstances, can enjoy and play hockey. My prior experience working for Sherwood Hockey during a co-op placement has given me insights into the design and manufacturing aspects of hockey equipment, making me even more invested in its improvement. Additionally, I believe that hockey is due for a change, as equipment design has remained relatively stagnant for a long time.

e) Explain this thesis topic along the following lines

The problem definition that is being addressed is that access to ice hockey is limited due to high costs associated with essential equipment, registration fees, and participation at advanced levels. At a micro level, cost is a significant barrier for individuals that want to try the sport. This can lead to exclusion and limiting participation to only those who can afford it. Increasing accessibility will also promote physical activity in players. On a macro level, increasing accessibility will lead to growing the sport to a more diverse hockey community. This problem definition meets the thesis criteria by allowing more people to enjoy the physical and emotional benefits of participating in hockey, leading to a healthier lifestyle. Also, of ergonomics this project will address solutions for a wide range of users. Lastly, sustainability will be addressed exploring the use of environmentally friendly materials and manufacturing techniques.





Appendix B – CONTEXTUAL RESEARCH (USER)

Expert Interview #1

Background of Interviewee

Name- Chris Snell
Contact- chris.snell@cantire.com
Basis of Expertise- Product development industrial designer at Sherwood Hockey

Transcript

Konnor
I'm doing this research into accessibility for youth ice hockey and this interview will help in my thesis research. This interview is completely voluntary and can be stopped at any time. Participation is anonymous and confidential. This conversation will be recorded. Do you agree to be to you being recorded?
Advisor
Yes.
Konnor
First question, how does cost affect the design of hockey equipment?
Advisor
I guess when you're designing hockey equipment, there's, there's two or three things that you consider. Protection, comfort and cosmetics for the design of it. I think that's like those are three pillars that you can kind of break it up into and generally when you lower or alter the cost, the swing of those 3 pillars are going to change. If you lower cost, either comfort goes down or protectiveness goes down and cosmetics stay the same or they all go down a little bit. Something always has to give and it depends on what that brand is trying to achieve. If they want something really flashy that looks good on the shelf, then they'll up the cosmetics. We've seen this before, like CCM does it with their youth line, the ultra tacks 2.0, which we looked at together. It looks cool and has cool graphics, but when you open it up there's not much going on, so the protective package took a hit so that the cosmetics could pull more of a marketing or shelf story together. It's really just by lowering the price, you're pulling something down, whether it's the cosmetics, the comfort or the protection package and it's up to the brand. How they want to lower that but. I'd say generally, you kind of bring everything down together at once. Simplify cosmetics, simplify the protection package, which in turn lowers the comfort level as well because it's less stitching, less cozy material, less comfortable straps perhaps. That makes it just a little less comfortable overall.
Konnor
For the next question, can you talk about a little bit about the role of customization in the design of hockey equipment?
Advisor
Different brands approach it differently. Sherwood is attempting to take risks with their product to make things a little more unique on the market so that if you are to buy that product, you have a piece of equipment that's a little bit different from what everyone else buys or a little bit different from the norm. So that could feel a little custom because it's the product is a little more bespoke compared to the mass market. So that's not really customization, but it's more a costumer finding uniqueness in a specific product which could feel custom to them. Other than that, there isn't a ton of customization in gear for standard consumers. Is that kind of what you mean, a standard consumer picking something off the shelf and customization at that level? Or team customization?
Konnor
Yeah, more like off the shelf product for a standard consumer.
Advisor
Sure, for off the shelf customization, some brands put a white 88 and for people to put their number. Obviously like color is a big thing. But at that level, there isn't a lot of customization in color. The gloves offered in black, blue and red and you choose the color closest to your team colors or if you're in a House league or a lower-level hockey, you choose whatever color glove you want. Other than that the big one would be stick and skate, which is something that Bauer is doing with their customization. It's kind of like a Nike ID, which I'm sure you're aware of. You customize your stick color which makes you feel like you're putting your own fingerprints on the graphics of your sticks to match your team or match what you like or making unique in a way. Now they're bringing that to the skates as well, to match your team colors but those are really only offered on premium products. It's not really offered on youth gears, it's not overly accessible and it's pretty a exclusive product. Other customizations, kids like to put like fun tape on their sticks or I even saw recently that Connor Bedard used to tape his blade all white and do drawings on the tape with a puck, funny for such an elite guy.
Konnor
Yeah, I'll like mention when I was playing the fish bowls came into style at one point, and everyone was wearing them.
Advisor
There's another like how you wear your equipment. So like your gloves, your helmet, your stick, your pants. Do you wear your pants like OV? Like all blown out with a big skate lace hanging down. Or is it more concealed in standard, or how do you tuck your shirt? Stuff like that. So there's an element of fashion in there for sure.
Konnor
Ok great, I'll go to the next question here. Do you believe that the design of hockey equipment impacts accessibility to the sport?

Advisor
I don't know if it's the design, like if we could make super simple stuff. At a super low price, which in some ways, we do. But if we could simplify the gear more and make it more affordable we could make it more accessible. The thing that's getting in the way is standards like impact protection standards and testing standards. Standards that you have to pass for like the rest of the world, and there's one in the states that you have to pass for use in North America. So that kind of gets in the way. But at the end of the day, if you're a youth kid, you're not really taking much impact. I'm sure there's a different standard for youth gear for necessary protection. I think there's definitely room to make stuff more affordable. Which would ultimately be a design challenge. It would be a design opportunity. But that would need to coincide with certain standards that are allowing you to pair things down to a point where cost is lowered. And you know maybe there's sneaky manufacturing methods or sneaky designs out there. There's gotta be something that just totally simplifies the shoulder pad. Less cuts, simpler patterns, less stitching, less layered material, maybe it's like more of a unibody thing. Yeah, I think there's opportunity out there, but it just needs to kind of coincide with the standards. Another issue is that hockey is a pretty slow-moving boat. Taking on culture, challenging equipment standards, challenging projects or products might take a while to be accepted. Like the Bauer extend kit. It's hard to imagine that will really take off. It's just a little too out there.
Konnor
Are there any specific challenges or considerations in designing equipment for youth players that you believe need more attention?
Advisor
Well, youth gear generally has less strapping. For a parent, an attractive piece of youth gear is something that they could imagine their kids like putting on themselves. We did a youth test youth fit test a few years ago with a bunch of like 9 or 10 year olds. When I was speaking to some of the parents they said this strapping is like too complicated, when we're in the room and it's like crazy, like when we showed up late and we just need get our kid dressed quickly and this strapping would drive me crazy. So I think simplified scrapping is an area that needs attention. Coming up with like simple strapping is a challenge. It's just something that hasn't really been considered. Another consideration for youth equipment is patterning. Kids have big heads compared to adults, so you need to account for that. Big heads in relation to their body. A lot of it is just proper patterning and choosing the right materials. At the end of the day, it's a pretty basic product like for youth sizes. We don't really make fancy products with fancy materials because it's really only to be used for a year or maybe two when kids are growing so fast. Things are made with relatively basic manufacturing processes.
Konnor
Do you believe there's market demand for sustainable hockey equipment?
Advisor
I think it needs to be eased in. I don't think there's a market for it right now because it's performance gear, its sports gear. If like if a company came out with a new top end stick, but it's made of recycled carbon fiber. Does that mean it's less durable or less strong? It's been used already, why would I use material that the second time around if it's the same price or more expensive. Probably more expensive to make that stick then the one with the new carbon. I think it's kind of a tough sell. We've done surveys before and the number one thing is protection and number two thing is durability. Just the way that it shakes out with making eco friendly or more sustainable products, they lack durability. It's like a substitute material for the ideal material. So getting around that is kind of tough in the marketing sense. I know we're running some tests on sustainability, like market tests and surveys on sustainability in the coming weeks. Going back to hockey, just being a slow moving boat. I don't know if the market is ready for it. I think it needs to go through a few other sports. They did like in the NHL a few years ago, I think for the All-Star game, they used the recycled parley Adidas for the jerseys. So that was a step in the direction. The jersey is just cosmetic, it's just on the outside. And apparently they were super hot. So it's kind of a tough sell on performance . Maybe it has a place in youth here because it's less based on performance. It's more based on that we have to strap something to you so that when you fall on your knees 100 times in a row. You're not taking an 80 mile an hour slap shot to your shin guards. It just needs to be strong and durable enough for you to keep falling on your knees and you'll use it for a year and a half, and then we'll pass it on to the next kid. There's probably a lot of young would be like young parents who would be more interested in buying a more sustainable product with recycled materials for their kid. Knowing that the product doesn't need to be like a high-performance, lightweight, air flow, high protection package product. It's just like - Let's make an amalgamation of simple, sustainable materials and make a decent product that works.
Konnor
Are there any technologies or products in the hockey industry that stand out to you right now?
Advisor
I think the sentiment behind the Bauer extend kit is good but I don't think it's achieving much and I don't know if there's much of a market buying that product, but that's just personal opinion. Other than that, hockey equipment has kind of been made the same way for a long time. It's purpose hasn't changed. I'm sure it's getting a little more lightweight and protection packages are going down a little bit as the game is getting faster so. It's just like the natural cycle of how hockey is played and the equipment is catching up to the style of playing. We were looking at the new CCM catalog with their new tacks product in it yesterday and it's the same. It's basically the same design as last time and the same product that came out two years ago with very slight adjustments. I think there's too much turn around in the Hockey world. The environment could benefit from less releases or less frequent releases. Bauer has a big development facility and I think every few years they put out an interesting product like their new Kinect goalies skates. Sherwood makes a youth kit now, too. Bauer does it as well, but the elbow pads are connected to the shoulder pads with like a compression sleeve, and the shin guard to connect to the pants with the compression sleeve - it's just simplifying the process of like putting the gear on by stringing the pieces of equipment together. So that's kind of an interesting solution. I don't really know if parents are drawn to that. I don't know if it sells well, but it's a product that made an effort to bring innovation. A lot of it is fashion.

It's making it look and sound cool. You saw the new jet speed stuff, how they had those sling features. I thought that was pretty innovative and cool.
Konnor
Lastly, do you have any other insights or suggestions you'd like to share regarding improving accessibility to hockey?
Advisor
It'd be interesting to kind of create a new standard like super baseline youth gear- maybe a kit. I think there's an opportunity there. Maybe it's not even one of the big brands. Maybe it's a different brand that's youth centered. That sets standard for youth kits cause across the board. Across brands, it's not really considering what does a four year old or a five year old like actually need in a shin guard. How do they actually need that to be strapped to their leg or what level of protection do they actually need? So it would be interesting to study. Study to see if you could kind of create a new standard. I think that's an interesting idea. If the number one thing is like hitting this price like what's affordable, what's in the realm of affordability for parents who are looking to get out their kid?

Expert Interview #2

Background of Interviewee
Name- Mack Seebach
Contact- (cell phone)
Basis of Expertise- Current youth hockey coach of several different age groups, both male and female
Transcript
Konnor
Please outline the age groups and skill levels you've coached during your hockey coaching career.
Advisor

- Boys Tyke House League
- Boys Novice A
- Boys Bantam Major A
- Boys Minor Midget A
- Boys Major Midget A
- Girls U18 AA

Konnor
What are the key barriers that young players face when it comes to accessing and participating in hockey? (Example: financial barriers, skill barriers)
Advisor
I would say that cost is likely the most prominent barrier with regards to access to hockey. Taking into consideration the registration fees, rep fees if applicable, travel cost (i.e. gas, food, hotels) and equipment the costs are significant.
Konnor
Describe any specific challenges related to affordability that you've observed among the youth players you've coached.

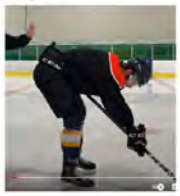
Advisor
I don't have any player specific examples; however I have been able to observe families and parent groups as a whole conduct planning for cost saving measures and fundraising. I think these things are valuable in making things potentially a little bit easier on families that may not have as much financial freedom as others.
Konnor
Do you believe that an inclusive team environment can help mitigate some of the barriers that young players face in accessing and participating in youth hockey?
Advisor
I think this is true. I believe that participation in team sports in general is extremely important for developing life skills that translate well into the professional world. That being said, hockey being portrayed as something inclusive could perhaps open that up to more people.
Konnor
Have you noticed any trends or changes in the youth hockey landscape with regards to accessibility and inclusivity?
Advisor
In recent years campaigns like "Hockey is for Everyone" is the first thing that comes to mind. Other things such as the use of pride tape is a seemingly small gesture that can make the game a space that's welcome to everyone or might make people consider playing more than they may have before if they viewed a lack of inclusivity as a barrier.
Konnor
What are your thoughts on the current availability of ice rinks and practice facilities in your community?
Advisor
This is a little outside of my realm, but I do understand that cost ties back into this. I think that availability of affordable ice at convenient times can be hard to find. Taking that into consideration, some organizations may find the need to look outside of their local facilities to find sufficient ice within their means/budget.
Konnor

How do you perceive the time commitments involved in youth hockey, including practices, games, and travel?
Advisor
This was something that I understated and misunderstood well into Jr. Hockey. I never understood or considered why my parents might have been a little frustrated that I was the last guy out of the room after an 8 PM game on a Tuesday night in Guelph. Reflecting on that now it was very obviously because we had to drive an hour 45 minutes home before they had to go to work at 8 AM. Time commitments are a huge part of participation in youth hockey. Parents may need to take time off of work or make arrangements with other families on the team to make sure that their kid makes it to hockey. Further, depending on what level of hockey their child is playing they may need to be at the rink 4-5 times a week. Having multiple children who play would only magnify that time commitment.
Konnor
Does your team participate in any financial assistance programs or fundraisers to help cover the costs of youth hockey?
Advisor
Unfortunately, I'm not sure.
Konnor
Are there any additional insights or suggestions you would like to share regarding improving accessibility to youth hockey?
Advisor
This is a tough one. More or larger programs like "Jump Start" that can help with some of the up front costs might be a good place to start.

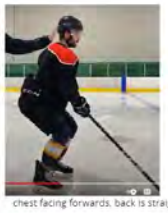
Appendix C – FIELD RESEARCH (PRODUCT)

Skating Posture

Skating Posture



bent over, curved back, cant bend knees, head down



chest facing forwards, back is straight, shoulders not in front of toes toes

feet shoulder width apart

Stride technique

Coach Kim's Corner #2 | Proper Stride Technique

wide feet, head down, leaning too far forward, wide arm swing across body, short strides.

The Forward Stride Analyzed - push angle, blade contact a...

PUSH ANGLE

push straight back in starting strides

as you pick up speed, push more laterally , increasing contact with the ice

Striding in forward skating:
Power is developed by taking fast, short strides. As speed increases, long and less frequent strides may be taken to maintain speed.
– Stride starts with feet close together and all weight on the pushing foot.
– Foot is turned 35–40°, and the push is to the side and down, pressing the blade deeply into the ice.
– As pushing foot is forced out to the side, the knee of the other leg is pushed forward.
– Push skating leg down and out as far as you can, until completely extended including ankle and foot extension to tip of toe.
– When stride is finished, the weight is transferred to the forward foot and pushing foot comes slightly off the ice.
– Knee of back leg is pulled forward with knee bending and pulled close to the gliding foot. Foot is kept close to the ice.
– You are now ready to start the next stride with the opposite foot.

IIHF Learn to Play Manual. International ice hockey federation. 2020
https://blob.iihf.com/iihf-media/iihfmvc/media/downloads/sport%20files/development-guide/lp/iihf_ltp_manual_20200929.pdf

Scorched Ice Smart skate module

gyroscope, accelerometer, temperature sensor, pressure sensor, wifi antenna, bluetooth antenna and rechargeable battery

Integrates sensor data collection, machine learning algorithms, and biomechanics to provide athletes with personalized insight and intelligence into their performance and development through real-time feedback.

Our solution collects left and right skate movements, toe pitch, edge roll, and foot acceleration enabling detailed stride analysis and skating performance feedback.

Our initial focus is on the following 5 key metrics: Activity, Intensity, Stride Count, Stride Dynamics & Power.

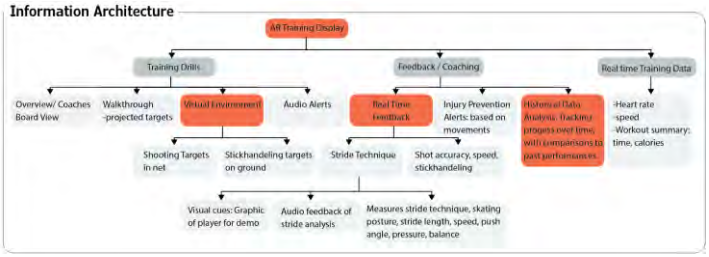
Two types of metrics:
1. Session Metrics include activity time, shift numbers & duration, stride count (left & right), intensity (peak & averages), intensity zones and intensity by shift.
2. Stride Metrics including Push, Recovery and Glide details, with explosiveness and efficiency in development.

Skating treadmills Challenges include: very high cost, requires large dedicated area, learning curve, safety concerns, not fully replicate ice skating feeling, requires trained technicians to maintain, repair, and operate

HockeyTracker iphone app for apple watch

Automatic Shift Detection* (including shift length, calories burned, top speed, and heart rates from each shift)
* Recovered (fresh) Heart Rate Alert
* High Heart Rate Alert
* Live-In-Game Stat Tracking
* Live In-Game summary of your last shift (duration, cals, distance, and avg speed)
• Game Scores
• Goals, Assists, and Plus-Minus Rating
• Calories Burned
• Distance Skated
• Heart Rates (including Max and Average Ice Time Heart Rates)
• Max and Average Skating Speed
• Ice time
• VO2 max**
• Heart Rate Recovery
• Maximum Capable Speed
• Hockey Fitness Level
• Skate Efficiency
* Effort Level
* Heart Rate Zone Analysis
• Longest, shortest and average shift times
• Historical graphs of all your metrics over time to see whether you're improving
• Shift Timer: set your desired shift time and get a haptic ping to tell you to get to the bench!
• Share your stats via text, email, Twitter, Facebook, Slack!
• Freshness Meter Complication so you know how prepared you are for your next session
• The notes section lets you keep track of how you played or describe goals, hits and penalties etc.
• Custom heart rate filtering algorithm that will filter out falsely high heart rate values

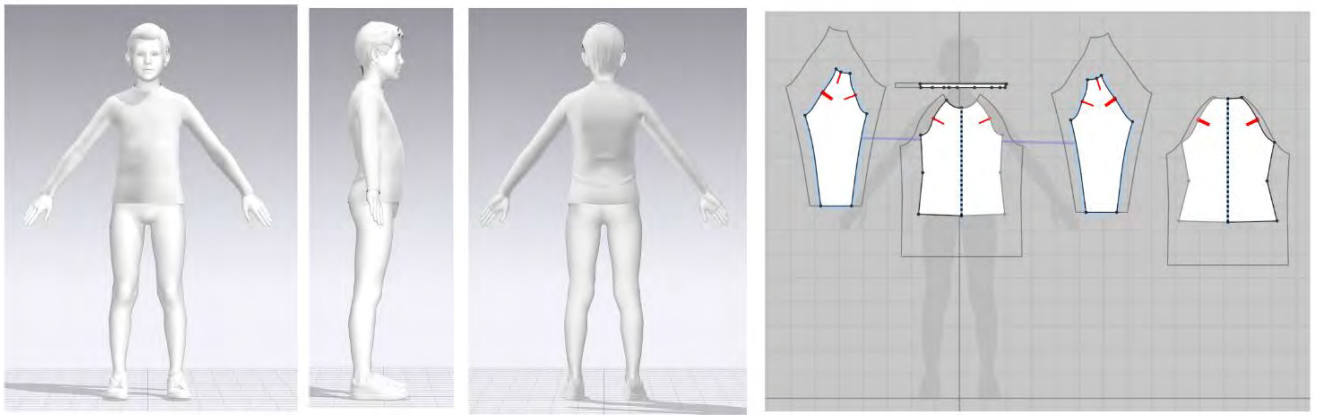
Appendix D – RESULTS ANALYSIS

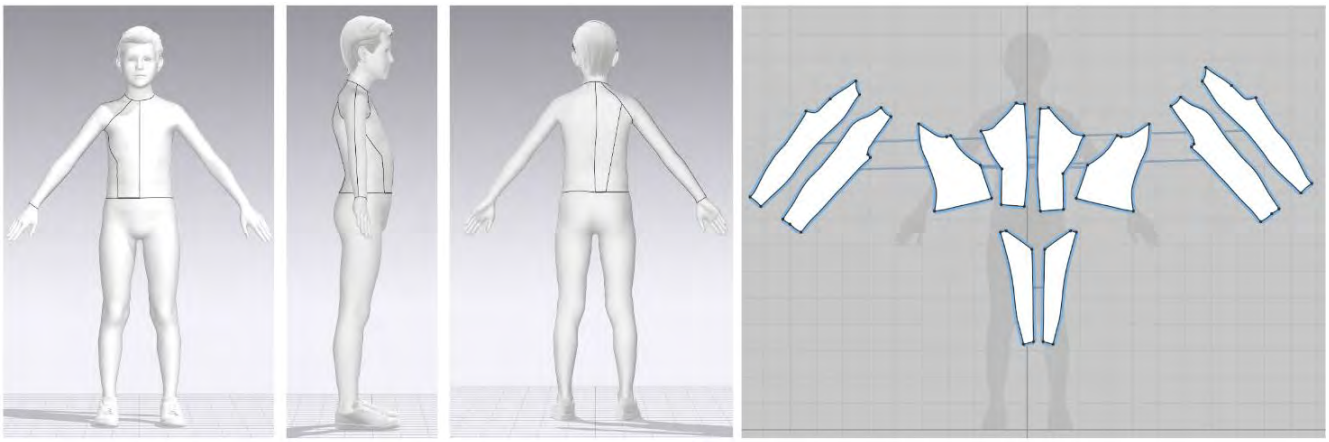


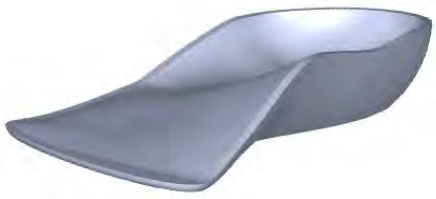
USER - PRODUCT- ENVIRONMENT OF USE triangulation - Mind Map

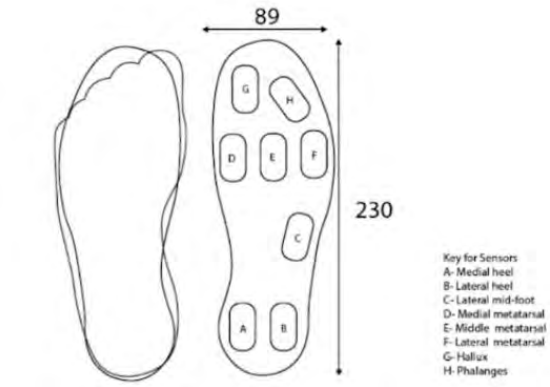
USER Primary, Secondary and Tertiary	PRODUCT Benchmarked Products	ENVIRONMENT OF USE Various Environments of Usage
Primary User: Youth Hockey Player Challenges include: high cost, access to ice nearby ice rink, level of play is highly competitive	Hockey Protective equipment Challenges include: high cost, children grow out and need to replace equipment often, non sustainable materials, feels bulky/ limits mobility	Ice hockey rink Challenges include: upkeep cost, limited use in summer months, scheduling all teams at all levels and age groups
Secondary User: Parent Challenges include: financial strain, time commitment, safety concerns, knowledge of the sport and available resources	Hockey Skates Challenges include: high cost, requires replacement as user grows, requires regular sharpening, can only wear and practice on ice, difficult to break in	Basement (inside house) Challenges include: limited space, noise, safety (walls, obstacles), damage to walls and furniture
Secondary User: Youth Hockey Coach Challenges include budget constraints, limited available ice time, trouble choosing team & evaluating players	Roller skates Challenges include: learning curve, safety concerns, limited use to flat and smooth surfaces, require wheel and bearing replacement, high quality comes with high cost, difficult to beak in	Driveway/ Backyard (outside house) Challenges include: avoiding obstacles like cars, uneven surface quality, subjected to weather conditions, limited space
Secondary User: Hockey Trainer Challenges include budget for equipment, developing training to improve player skill, helping players individually	Synthetic ice / shooting pads Challenges include: high initial cost, requires maintenance, not same surface feeling as ice- difficult to get used to, tiles wear down over time, caused more wear to skate blades	Gym Challenges include: not specific to hockey training (can't use sticks or pucks), lack of space for full-scale hockey drills
Secondary User: Local Hockey Organizations Challenges include: relying on volunteers, finding coaches, declining enrollment, balancing cost of facilities while trying to keep fees reasonable, inclusivity	Skating treadmills Challenges include: very high cost, requires large dedicated area, learning curve, safety concerns, not fully replicate ice skating feeling, requires trained technicians to maintain, repair, and operate	School (primary/ secondary) Challenges include: limited budget for sports equipment, teacher expertise, smaller schools do not have ice hockey teams due to cost and lack of participation
Tertiary User: Sponsors Challenges include raising money to be donated to local teams, ensuring continued support each year, measuring effectiveness of their contributions	Shooting targets and tarps Challenges include: durability, require ample space to set up, limited top shooting training only, hard to translate to shooting in stride in real game situations	Outdoor hockey rinks Challenges include: weather and season dependent, maintaining quality of ice, safety, bringing out equipment like nets which can be difficult to move.
Tertiary User: Hockey Scouts Challenges include evaluating players in leagues with different levels of competition, evaluating players in different locations, lack of in-depth metrics for evaluating player ability, no "universal evaluation"	Rebounders/ Passing devices Challenges include: durability, hard to use with limited space, difficult to transfer skills to actual on ice play	Hockey tournaments Challenges include: often require lots of travel, registration cost, often require hotels, large time commitment (often taking time off work and school)
Tertiary User: Professional Hockey teams Challenges include: financial constraints, player recruitment, growing a fanbase, player development	Off ice pucks/ stickhandling balls Challenges include: often do not replicate on ice feel, weighted stickhandling balls can weaken stick blade	Street Challenges include: uneven surface quality, weather, safety, increased wear to sticks, obstacles like parked cars
Tertiary User: Hockey Equipment Manufacturer Challenges include making equipment that is meets quality and safety standards while balancing affordability, market competition that demands innovation and accessibility	Stickhandling training: Superdeker, hockeyshot speed deke kit, hockeyshot extreme defender Challenges include: skill transferability, durability, cost	Professional hockey rinks Challenges include: high maintenance cost (energy to control lights and temperature), prioritize professional hockey, often not open for public use, high cost to rent
Tertiary User: Government Challenges include ensuring the availability and affordability of ice rinks, allocating funding to promote hockey, prompting physical activity for a more healthy youth population	Hockeyshot slide board pro Challenges: not slick enough over time, durability, stability of board- board shifts on the ground making product hard to use, shoe covers rip, challenging and awkward to use, requires glide spray	Universities and Colleges Challenges include: maintenance cost including supporting team locker rooms, training facilities, scheduling,

Appendix E – CAD DEVELOPMENT









Appendix F – PHYSICAL MODEL PHOTOGRAPHS

Appendix J – APPROVALS & PLANS

THESIS TOPIC APPROVAL Bachelor of Industrial Design / FALL 2023

Student Name:	Konnor Luciani
Topic Title:	How might we improve accessibility to ice hockey for youth?

TOPIC DESCRIPTIVE SUMMARY (PRELIMINARY ABSTRACT)

In Canada the sport of ice hockey holds a central place in culture and identity, however accessibility to the sport has become an increasingly pressing issue. The high costs associated with equipment, training, league fees, ice time, and travel have limited the participation of youth from diverse socio-economic backgrounds. This problem not only restricts the sport's reach but also hinders the physical activity and well-being of Canadian youth. To address this issue, this thesis will explore ways of improving accessibility to ice hockey for youth. It takes into account the macro perspective of the sport's cultural significance in Canada and the need for inclusivity. At the micro level, the evaluation and analysis will involve observational studies, interviews, and surveys to understand the challenges faced by youth players, parents, coaches, and hockey organizations. The future findings of this research aim to bridge the gap between the macro and micro perspectives by proposing innovative solutions that not only make hockey more accessible but also align with broader social responsibility goals. These solutions will enhance the lifestyle of Canadian youth, improve ergonomics and user experience, and contribute to sustainability efforts. Ultimately, this research seeks to ensure that the unifying force of hockey in Canada is truly accessible to all, regardless of financial circumstances, fostering a healthier and more inclusive future for the sport.

Student Signature(s):	Konnor Luciani
Date:	26/09/2023
Instructor Signature(s):	Catherine Chang
Date:	02 October 2023

21 Chong, Kappen

PANEL ON RESEARCH ETHICS
Navigating the ethics of human research

TCPS 2: CORE 2022

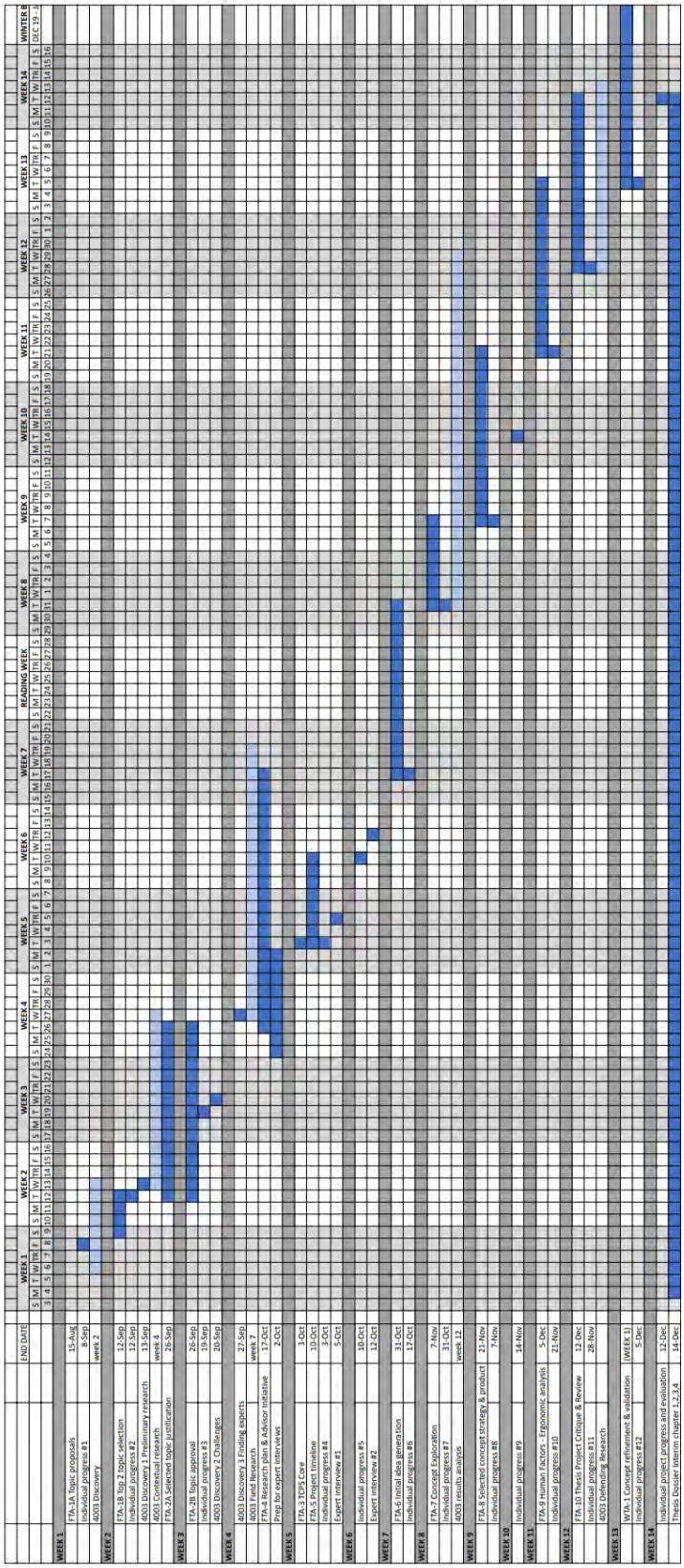
Certificate of Completion

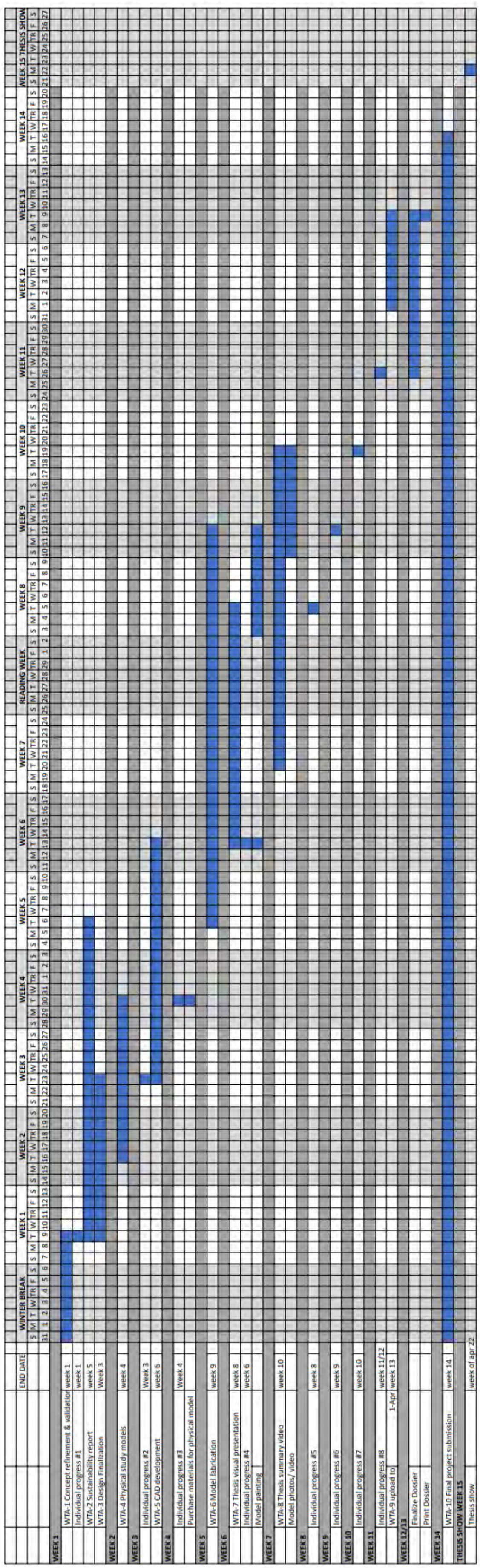
This document certifies that

Konnor Luciani

successfully completed the Course on Research Ethics based on the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 2: CORE 2022)

Certificate # 0000953373 **8 September, 2023**




END DATE
WINTER BREAK
WEEK 1
WEEK 2
WEEK 3
WEEK 4
WEEK 5
WEEK 6
WEEK 7
READING WEEK
WEEK 8
WEEK 9
WEEK 10
WEEK 11
WEEK 12
WEEK 13
WEEK 14
WEEK 15 THESIS SHOW
WEEK 1
WTA-1 Concept refinement & validation week 1
Individual progress #1 week 1
WTA-2 Sustainability report week 5
WTA-3 Design Finalization Week 3
WEEK 2
WTA-4 Physical study models week 4
WEEK 3
Individual progress #2 Week 3
WTA-5 CAD development week 6
WEEK 4
Individual progress #3 Week 4
Purchase materials for physical model
WEEK 5
WTA-6 Model fabrication week 9
WEEK 6
WTA-7 Thesis visual presentation week 8
Individual progress #4 week 6
Model painting
WEEK 7
WTA-8 Thesis summary video week 10
Model photos/ video
WEEK 8
Individual progress #5 week 8
WEEK 9
Individual progress #6 week 9
WEEK 10
Individual progress #7 week 10
WEEK 11
Individual progress #8 week 11/12
WTA-9 upload to 1-Apr week 13
WEEK 12/13
Finalize Dossier
Print Dossier
WEEK 14
WTA-10 Final project submission week 14
THESIS SHOW WEEK 15
Thesis show week of apr 22

Research Plan

Research Elements- Research will be conducted to determine the current state of accessibility by gathering data including the cost breakdown of participating in youth ice hockey, youth hockey demographics. Research will also be conducted into existing solutions and benchmarking current products. Analysis of user experience will be conducted to better inform a solution.

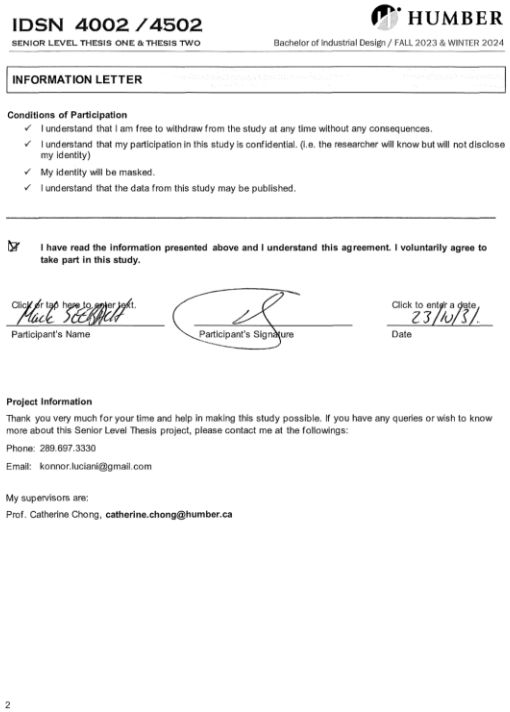
Research Methods- The research plan encompasses both secondary and primary research methods. Secondary research will involve extensive exploration through the Humber library database and internet searches, gathering existing knowledge and data. Primary research will revolve around in-depth interviews with field experts. The data gathered will then be compiled and analyzed, identifying trends that reveal the significance of the problem and trends that the design of a well-informed solution.

Interviews- The general focus for interview questions is to gather insights and information from individuals with experience in youth hockey coaching, as well as those involved in the design and manufacturing of hockey equipment. The purpose of the interviews is to acquire valuable insights into user experiences, the challenges hindering accessibility, and the current strategies in hockey equipment design.

Research Schedule- In the first week, the focus is on initial research for topic proposals, encompassing the background of the subject. Weeks 2 to 4 are allotted for conducting research for topic justification and gaining approval. This phase includes delving into the historical and social context of the topic, understanding user groups and demographics, benchmarking existing products and solutions, and assessing the environment of use. Weeks 5 to 9 include further in-depth benchmarking, and data collection to gain a deeper understanding of the topic.

Weeks 11 to 14 will focus on human factors and ergonomics research.

Appendix K – ADVISOR MEETINGS & AGREEMENT FORMS



IDSN 4002 / 4502
SENIOR LEVEL THESIS ONE & THESIS TWO
HUMBER
Bachelor of Industrial Design / FALL 2023 & WINTER 2024

INFORMATION LETTER

Conditions of Participation

- ✓ I understand that I am free to withdraw from the study at any time without any consequences.
- ✓ I understand that my participation in this study is confidential. (i.e. the researcher will know but will not disclose my identity)
- ✓ My identity will be masked.
- ✓ I understand that the data from this study may be published.

☒ **I have read the information presented above and I understand this agreement. I voluntarily agree to take part in this study.**

Click or tap here to enter text. Mark SEEBACH — Participant's Name
Participant's Signature
Click to enter a date. 23/10/31 — Date

Project Information

Thank you very much for your time and help in making this study possible. If you have any queries or wish to know more about this Senior Level Thesis project, please contact me at the followings:

Phone: 289.697.3330

Email: konnor.luciani@gmail.com

My supervisors are:

Prof. Catherine Chong, **catherine.chong@humber.ca**

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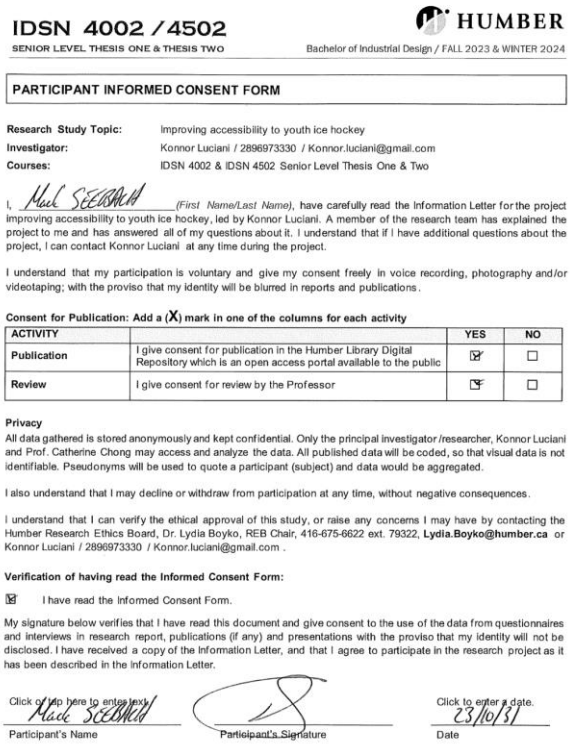

IDSN 4002 / 4502
SENIOR LEVEL THESIS ONE & THESIS TWO
HUMBER
Bachelor of Industrial Design / FALL 2023 & WINTER 2024

PARTICIPANT INFORMED CONSENT FORM

Research Study Topic: Improving accessibility to youth ice hockey
Investigator: Konnor Luciani / 2896973330 / Konnor.luciani@gmail.com
Courses: IDSN 4002 & IDSN 4502 Senior Level Thesis One & Two

I, Mark SEEBACH *(First Name/Last Name)*, have carefully read the Information Letter for the project improving accessibility to youth ice hockey, led by Konnor Luciani. A member of the research team has explained the project to me and has answered all of my questions about it. I understand that if I have additional questions about the project, I can contact Konnor Luciani at any time during the project.

I understand that my participation is voluntary and give my consent freely in voice recording, photography and/or videotaping; with the proviso that my identity will be blurred in reports and publications.

Consent for Publication: Add a (X) mark in one of the columns for each activity

ACTIVITY		YES	NO
Publication	I give consent for publication in the Humber Library Digital Repository which is an open access portal available to the public	☒	☐
Review	I give consent for review by the Professor	☒	☐

Privacy

All data gathered is stored anonymously and kept confidential. Only the principal investigator /researcher, Konnor Luciani and Prof. Catherine Chong may access and analyze the data. All published data will be coded, so that visual data is not identifiable. Pseudonyms will be used to quote a participant (subject) and data would be aggregated.

I also understand that I may decline or withdraw from participation at any time, without negative consequences.

I understand that I can verify the ethical approval of this study, or raise any concerns I may have by contacting the Humber Research Ethics Board, Dr. Lydia Boyko, REB Chair, 416-675-6622 ext. 79322, **Lydia.Boyko@humber.ca** or Konnor Luciani / 2896973330 / Konnor.luciani@gmail.com .

Verification of having read the Informed Consent Form:

☒ I have read the Informed Consent Form.

My signature below verifies that I have read this document and give consent to the use of the data from questionnaires and interviews in research report, publications (if any) and presentations with the proviso that my identity will not be disclosed. I have received a copy of the Information Letter, and that I agree to participate in the research project as it has been described in the Information Letter.

Click or tap here to enter text. Mark SEEBACH — Participant's Name
Participant's Signature
Click to enter a date. 23/10/31 — Date

IDSN 4002 / 4502
SENIOR LEVEL THESIS ONE & THESIS TWO
HUMBER
Bachelor of Industrial Design / FALL 2023 & WINTER 2024

INFORMATION LETTER

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- ✓ My identity will be masked.
- ✓ I understand that the data from this study may be published.

☒ **I have read the information presented above and I understand this agreement. I voluntarily agree to take part in this study.**

CHRISTOPHER SNELL — Participant's Name
Participant's Signature
2023-10-05 — Date

Project Information

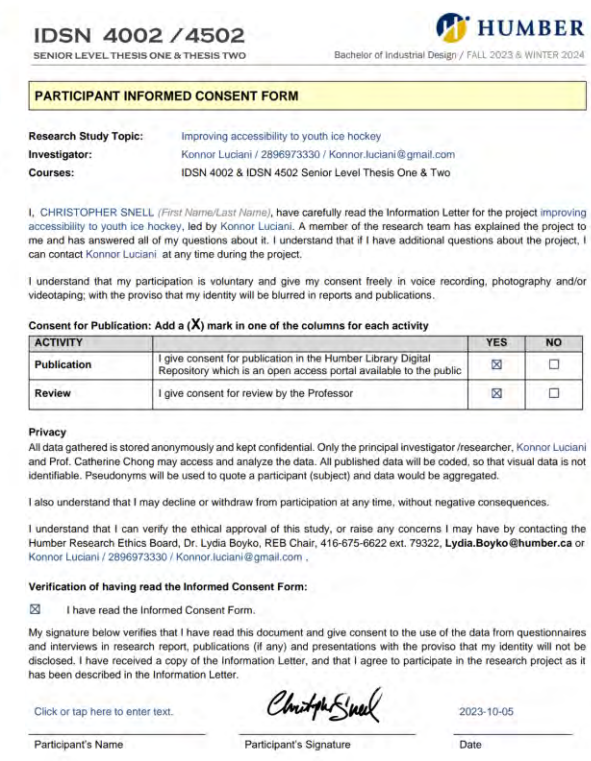
Thank you very much for your time and help in making this study possible. If you have any queries or wish to know more about this Senior Level Thesis project, please contact me at the followings:

Phone: 289.697.3330

Email: konnor.luciani@gmail.com

My supervisors are:

Prof. Catherine Chong, **catherine.chong@humber.ca**



IDSN 4002 / 4502
SENIOR LEVEL THESIS ONE & THESIS TWO
HUMBER
Bachelor of Industrial Design / FALL 2023 & WINTER 2024

PARTICIPANT INFORMED CONSENT FORM

Research Study Topic: Improving accessibility to youth ice hockey
Investigator: Konnor Luciani / 2896973330 / Konnor.luciani@gmail.com
Courses: IDSN 4002 & IDSN 4502 Senior Level Thesis One & Two

I, CHRISTOPHER SNELL *(First Name/Last Name)*, have carefully read the Information Letter for the project improving accessibility to youth ice hockey, led by Konnor Luciani. A member of the research team has explained the project to me and has answered all of my questions about it. I understand that if I have additional questions about the project, I can contact Konnor Luciani at any time during the project.

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Privacy

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Click or tap here to enter text. — Participant's Name
Participant's Signature
2023-10-05 — Date

Appendix M – TOPIC SPECIFIC DATA, PAPERS, PUBLICATIONS

www.nature.com/scientificreports

scientific reports

OPEN

Measurement of temporal and spatial parameters of ice hockey skating using a wearable system

Aminreza Khandan, Ramin Fathian, Jason P. Carey & Hossein Rouhani

Ice hockey is a dynamic and competitive sport that requires a high level of neuromuscular and cardiovascular function. An objective assessment of skating helps coaches monitor athletes' performance during training sessions and matches. This study aimed to estimate the temporal and spatial parameters of skating by proposing an optimized configuration of wearable inertial measurement units (IMUs) and validating the system compared to in-lab reference systems. Ten participants were recruited to skate on a 14 m synthetic ice surface built in a motion-capture lab. Eight original event detection methods and three more adopted from gait analysis studies were implemented to detect blades-off and skate-strikes. These temporal events were detected with high accuracy and precision using skate-mounted IMUs. Also, four novel stride length estimation methods were developed to correct the estimated skaters' position using IMUs' readouts. The stride time, contact time, stride length, and stride velocity were obtained with relative errors of 3 ± 3%, 4 ± 3%, 2 ± 6%, and 2 ± 8%, respectively. This study showed that the wearable IMUs placed on skates and pelvis enables the estimation of temporal and spatial parameters of skating with high accuracy and precision, which could help coaches monitor skaters' performance in training.

Ice hockey requires high levels of aerobic and anaerobic fitness, well-coordinated body motion, and efficient functioning of the neuromuscular and cardiovascular systems[1–3]. Players with higher neuromuscular and cardiovascular abilities, capable of starting quickly and skating at higher speeds, are more likely to possess the puck and win face-to-face competitions in matches[4]. Accurate assessment of hockey players' skating movements during training sessions can help coaches continuously monitor players' performance with the aim of improving it during training. Spatial [e.g., stride length (SL) and velocity (SV)] and temporal [e.g., stride time (ST) and ice contact time (CT)] parameters of skating serve as mobility biomarkers[5,6] and are recognized as significant metrics to characterize any repetitive activity like forward ice striding. These parameters, traditionally, were obtained in human motion laboratories using stationary motion-capture (MoCap) systems. However, the application of these instruments is limited since they are not available in every ice rink, and their captured volume is confined to a small part of the ice rink, which can disrupt the natural skating patterns of ice skaters[7,8]. Thus, wearable and garment-embedded technologies are preferable for on-ice skating performance assessments[9–11].

Buckeridge et al. used a portable system composed of accelerometers, EMG modules, and force sensors to assess on-ice hockey player performance[12]. Also, Stetter et al. studied the feasibility of using wearable accelerometers to identify skating parameters such as ST and CT to differentiate players in terms of their skill level[13]. However, these studies investigated the skating parameters using 3D accelerometers rather than inertial measurement units (IMU). IMU has been applied to measure human motion for clinical outcome evaluation[14–16], sport biomechanics evaluations[17–22], and movement modalities detection[14,20]. They have the potential to obtain temporal and spatial parameters during hockey skating.

The computation of the temporal and spatial parameters, in the first step, requires the detection of skating temporal events. The accuracy of event detection using IMUs can vary significantly depending on the extraction method used[17–19]. The second step is to estimate the participant's trajectory in each stride necessary to calculate the spatial parameters[23]. Finally, temporal and spatial parameters can be calculated by the detected temporal events and the participants' trajectories. Participants' trajectory can be calculated using double-time integration of the participant's acceleration in a global reference frame. However, due to the cumulative error in the numerical

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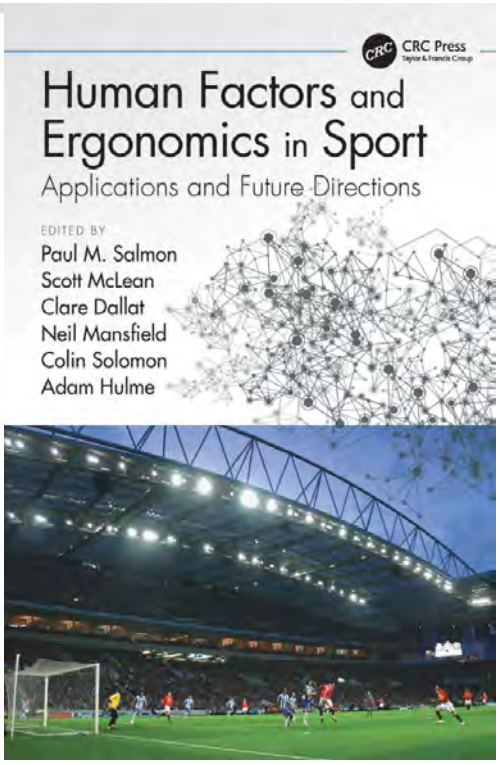

CRC Press
Taylor & Francis Group

Human Factors and Ergonomics in Sport

Applications and Future Directions

EDITED BY

Paul M. Salmon
Scott McLean
Clare Dallat
Neil Mansfield
Colin Solomon
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Sensor Technology for Ice Hockey and Skating

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Swiss Federal Institute of Technology
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***Abstract*—Sensor technology that is unobtrusively integrated into the clothing and equipment of an athlete can support the training of sport activities and monitor the athlete's progress. In this paper, we propose two wearable systems that support ice hockey players in the training of skating and shooting. These assistants measure the motions of players and compare them with reference executions of the same activities by professional players. A third system that we introduce monitors the player's activities during a hockey game and creates a match report for objective performance measurement. For each of the three proposed applications, we present a prototype setup that we evaluate with amateur and professional players. The main findings are i) that with a skate-worn motion sensor and user-dependent training, eight skating motions can be spotted with an accuracy above 90%, ii) that stick-integrated sensors enable the measurement of relevant shot features, which differentiate professional from amateur athletes, and iii) that it is possible to spot important ice hockey activities in the signals of body-worn motion sensors worn during a game.**

I. Introduction

Ice hockey is a fast and intense sport played worldwide by 1.7 million licensed and many more hobby players in non-official leagues [1]. Relevant skills for hockey players include ice skating, the handling of the hockey stick and physical plays such as body checking and fist fights [2]. To learn how to shoot while moving at speeds of up to 30 km/h requires a high level of coordination and much practice. Even though players wear protectors for all body parts, they are at a high risk of injuries, in particular concussions due to hits against the head [3].

For the study of injuries, to improve hockey and skating equipment, and as a complementary tool to professional coaching, wearable sensor setups have been proposed. Previous work includes the development of a sensor-based system for analyzing power strokes, the main accelerating motion in skating [4], and helmet-integrated inertial sensors for monitoring the high impacts during hockey playing. These impacts may result in concussions and spine-related injuries [5]. With the FWD PowerShot[1] device by Qualitrainer, a system for measuring the timing of shooting motions in hockey is commercially available. Furthermore, literature presents a variety of research prototypes and commercial systems for related team sports, in particular for American football [6], field hockey [7] and baseball [8].

[1] http://www.qualitrainer.com/en/powershot/

In this paper, we discuss potential applications for state-of-the-art wearables in skating and hockey, and we present prototype systems and their evaluation with amateur and professional players. We thereby focus on the following aspects:

- **Skating:** We present the *SkateTracker* system for monitoring skating and recognizing relevant events, in particular *power strokes*, *breaking*, *turns*, *jumps* and *curves*. The system provides basic statistics about each movement, e.g., the timing and intensity of *power strokes*. Given the similar motion patterns, the same system is also tested in inline skating, which is a popular sport by itself: According to [9], 13 – 19 million people go inline skating regularly in the US alone. To the best of our knowledge, SkateTracker is the first *step counter* optimized for the typical skating motion patterns.
- **Shooting:** Previous research on shooting techniques in ice hockey used high-speed cameras and motion capturing [10], [11]. However, camera-based systems are not applicable in regular training situations because of the associated installation effort. The above-mentioned, stick-integrated FWD PowerShot[1] system can track stick orientation and timing, but it does not consider other characteristics of a shot execution such as the hand positions on the stick. In this work, we equipped the *Sensorized Hockey Stick* with motion sensors, strain gauges and pressure-sensitive potentiometers. With the sensorized hockey stick, players can measure the stick's motion in space, its flexion, and the hand positions while playing. The stick wirelessly transmits data to a smartphone for provision of feedback that helps to improve the shooting technique. The system automatically differentiates between shot types, and recognizes the user's skill level based on his handling of the device.
- **Gameplay:** In soccer and other sports, sensor-based game monitoring already proved to provide relevant information about an athlete's performance [12]. For ice hockey, no such system exists as of now. We present the wearable sensor setup *GameTracker* for the identification of relevant hockey game events, such as *hits*, *shots*, *time in motion*, etc. This wearable monitoring system can provide statistics about a game without the need for external surveillance.

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sports

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Review

Associations between Testing and Game Performance in Ice Hockey: A Scoping Review

Vincent Huard Pelletier [1,2,*], Julien Glaude-Roy [2,3], André-Philipe Daigle [1,2], Jean-François Brunelle [2,3], Antoine Bissonnette [1,2] and Jean Lemoyne [1,2]

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* Correspondence: vincent.huard.pelletier@uqtr.ca

Abstract: Background: Despite the exhaustive body of literature on the demands of ice hockey, less is known about the relationships between functional performance testing protocols (on ice and off ice) and performance in a game situation. The objective of this review is to provide an overview of these associations. Methods: This review aims to identify on- and off-ice testing currently used in the scientific literature and their possible transfer to game performance as well as identifying research gaps in this field. Results: The 17 selected studies showed that off-ice and on-ice fitness test results can be modestly transferred to the player's selection as well as global and advanced performance indicators. Conclusion: This review of the literature reinforces the importance of strength and conditioning coaches administering previously validated fitness tests. Regarding the academic research, it is also proposed to use performance markers that are directly related to the players' on-ice performance to represent more accurately the relationship between the players' fitness level and their work output. Three research gaps were also identified in relation to targeted populations, choice of performance markers and data measurement methods.

Keywords: functional performance; fitness; sports; athletic development; performance assessment; physical activity

Citation: Huard Pelletier, V.; Glaude-Roy, J.; Daigle, A.-P.; Brunelle, J.-F.; Bissonnette, A.; Lemoyne, J. Associations between Testing and Game Performance in Ice Hockey: A Scoping Review. *Sports* **2021**, *9*, 117. https://doi.org/10.3390/sports9090117

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1. Introduction

Subsequent to the legendary Summit Series in 1972, ice hockey was recognized as an international sport, which resulted in an invitation to professional players to compete at the Nagano Olympics in 1998. In 2020, over 1.6 million players took to the ice in more than 70 countries [1]. Thanks to this worldwide interest, hockey federations in each nation now look for ways to optimize player development, while aiming to meet the highest standards. This tendency has also generated substantial scholarly interest in the last two decades. For example, a search using the keyword "ice hockey" on the Google Scholar database, filtered for the number of academic publications between 2000 and 2019, revealed a large increase in ice hockey scholar publications: 4000 (2000–2001), 11,000 (2009–2010), and 16,500 (2019–2020).

The seminal works of Montgomery [2], Cox [3], and Bracko [4] provide a comprehensive overview of the intense and multifactorial nature of high-level ice hockey. Sports science publications can in fact be classified into four groups of attributes: physical, technical, tactical, and cognitive-psychological. Morphological characteristics are also believed to play a key role in player selection at the elite level [5]. Even when hockey is played at high


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