Basketball Footwear Design: The Guard Position
Integration of performance, injury prevention and style.

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Abstract

Basketball is the world's most popular indoor team sport and was the most watched team sport of the 2016 Rio Olympic Games. Basketball shoes are frequently linked to player performance and are arguably the most important innovative product connected to the sport. Benefits attributed to this product include: reducing injury rates, minimizing energy expenditure and enhancing athletic performance.

While the large number of basketball players presents a commercial market to footwear manufacturers, basketball shoes are not only worn by basketball players. The popularity as a spectator sport has expanded the commercial market, as basketball fans purchase shoes to emulate their heroes. In addition to this, sneakerheads (a subculture of sneaker lovers) purchases new and innovative designs as fashion apparel as an integral part of their lifestyle. Designing a new shoe that provides professional players with performance benefits and fashion aficionados with fresh interesting designs is essential, as high-profile players often represent fashion brands.

Basketball has five different player positions on court, each with specialised locomotion requirements and high physical contact. Understanding performance requirements of specific positions, and human physiology constraints allows design to extract new benefits, advancing player performance. Integrating this advantage with aesthetic and fashion development provides the opportunity to develop a fresh new concept basketball shoe. This design focuses on a shoe that provides injury prevention, performance and a fresh aesthetic design for professional basketball players in the guard position.

Keywords:

Basketball, footwear design, injury prevention, performance, fashion, integration, industrial design

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1.0. Introduction

With an estimated 450 million players worldwide, basketball is the world's most popular in-door team sport, and was the most watched team sport of the Olympic Games (FIBA. Basketball). A core component of playing basketball is the basketball shoe, and this product has developed over the last hundred years (Sneakers) through new materials, technology and manufacturing improvements. Basketball footwear innovation continues to play an important role in the development and profile of the game. Basketball shoes are no longer the exclusive domain of the basketball player but have migrated into global fashion.

The basketball shoe is arguably the most important innovative product connected to the game of basketball. Innovative shoes and boots are launched regularly, and their designs are frequently linked to aspects of player performance(Miller J.E et at 759), such as reducing injury rates, minimizing energy expenditure (Luo G et al. 25), and enhancing athletic performance (Frederick EC and Wojcieszak C 339). By looking at contemporary sports science research and materials developments, new concepts for basketball shoes can be generated that deliver improved performance and aesthetic benefits for players as well as fashion conscious fans and sneakerheads.

I enjoy playing basketball with friends and following teams and players. It is a great sporting passion of mine. As a shoe designer, participating in the sport keeps me attuned to the latest basketball shoe innovations, design strategies and styles. This research project has allowed me to bring two passions together, design and basketball. Through the development of a concept basketball shoe. My intention is a connect aspects of industrial design, fashion design and sport science to present an innovative new concept shoe designed specifically for professional basketball players who play in the guard position. Using selected features of existing shoes, modifying, improving and reducing the components and processes involved in manufacture, improved material selection and introducing new design features, I will be able to improve the usability, desirability and sustainability of the product concept. This practice-based research project will conclude with an aesthetic 'look-alike' prototype and be supported with materials and technology investigations and 2D design investigation and visualisation.

2.0. Research Method

The aim of this research is to:

1. Design a concept basketball shoe that incorporates injury prevention features without reducing athletic performance.
2. Integrate these benefits with an innovative aesthetic that communicates the performance advantage.

My research methodology addresses six research questions:

1. Does redesign of a basketball shoe provide benefit or value for the commercial market?
2. How does foot anatomy behave when playing basketball?
3. What are the most common injuries to basketball players, with their causes?
4. Are there different shoe requirements for players in different playing positions, and how does this affect shoe design?
5. What is the general product architecture and characteristics of a basketball shoe?
6. How have different shoe brands used design to solve problems and how has this been expressed?

I took a pragmatic approach to this study, using information identified in my research context to direct my investigations into the key elements relevant to design a shoe for basketball players in the guard position, through primary research and research through design.

Primary research was undertaken to gain connection with, and insights from the field:

1. I trained and played with professional basketball players to better understand the movements in a game.
2. I documented changes to shoe and foot during a two-month period of play.
3. I interviewed professional players for their perspectives on the features needed in a shoe.
4. I deconstructed shoes to better understand the components, materials and manufacturing processes involved in their build.

My design integrates these findings and addresses research questions through design a series of design investigations addressed in Chapter 6.

3.0. Research context

The research context was informed by literature, including investigations into: market potential; foot anatomy and support related human factors (action and force, locomotion, basketball common injuries and injury prevention); player position; and basketball shoe design.

3.1. Market potential

The International Basketball Federation (FIBA), an association of national organizations which governs international competition in basketball, states there are 450 million basketball players worldwide (FIBA. Basketball). This large number of players presents a commercial value to footwear manufacturers, but basketball's popularity as a spectator sport also contributes to market size. Basketball is the world's most popular indoor team sport and the most watched team sport at the Olympic Games (FIBA. Basketball). People like to imitate their heroes, especially National Basketball Association (NBA) superstars like Michael Jordan and Kobe Bryant. These sporting superstars have millions of fans all over the world and have branded basketball shoes bearing their names. The translates directly to shoe sales, as evidenced in sales figures (Figure 1).

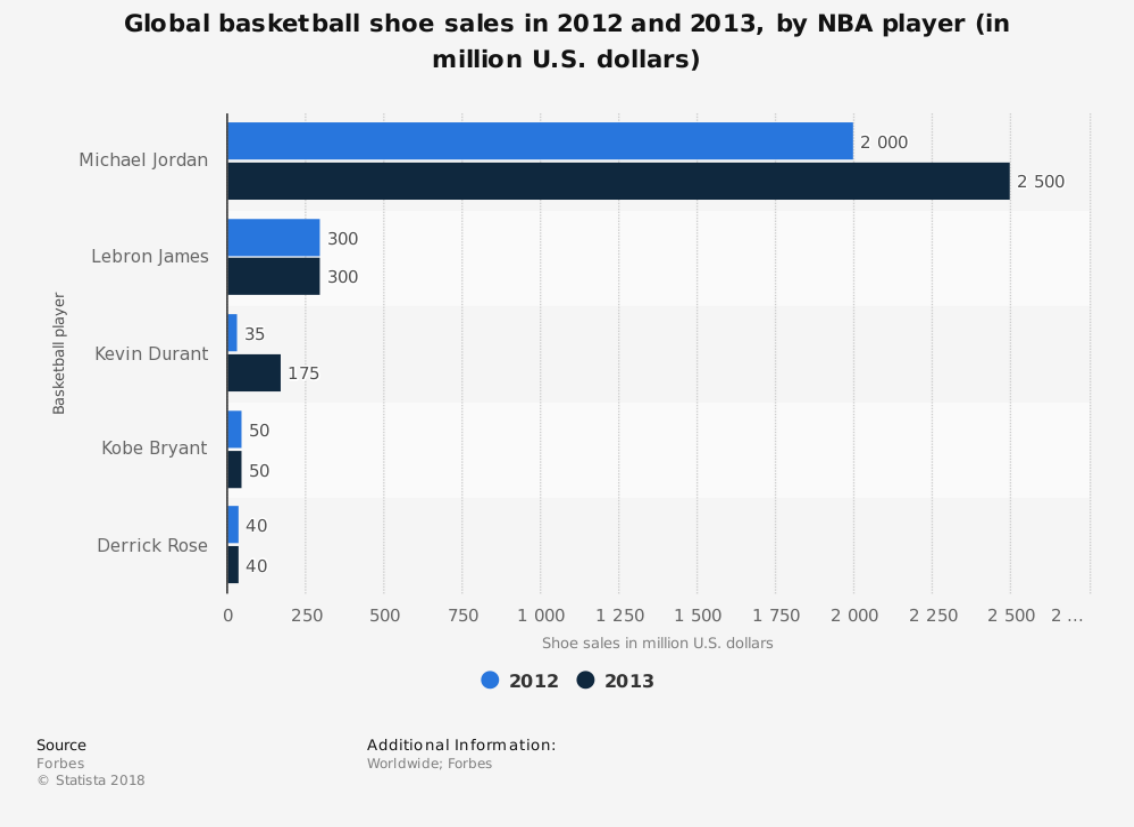

Figure 1. Global basketball shoe sales in 2012 and 2013, by NBA player

In 2013, Michael Jordan shoes accounted for $US 2500 million in sales, up from $US 2000 million the previous year. Other players' shoes have sold over $US 500 million in 2013.

Expanding this market further is a phenomenon known as the sneaker subculture. Sneakers generally describe a type of footwear with a flexible sole made of rubber or synthetic material and primarily designed for sports.

Figure 2. Examples of Sneaker Type

The collective term ‘sneakerheads’ has been applied to those who appreciate or collect sneakers. This underground subculture developed in New York after Nike released the first ‘Nike Air Jordan’ in 1985. The shoe was named after legendary American basketball player Michael Jordan, and Kawamura named this as "The Second Wave Sneaker Phenomenon" (Kawamura, Yuniya 44). Basketball shoes are known for adopting innovative features improving on-court performance, but a significant characteristic of the fashion focused sneakerhead market is concerned with contemporary aesthetics. In summary, the demand for basketball shoes is not limited to basketball players, but includes a broader market of players, fans, and fashionistas.

3.2. Foot anatomy

The human foot is a strong and complex mechanical structure that includes 26 bones, 33 joints, and more than a hundred muscles, tendons, and ligaments that give support to the body (Bonnel F et al 1). The biomechanical function of the foot is a key consideration for the design of a shoe. Each part of foot provides a specific function that affects the body, and in particular, the lower limbs and extremities. For instance, the ankle joint acts as a pivot point and connects the lower leg and foot, allowing the foot to complete four fundamental movements: plantar flexion, dorsiflexion, inversion, and eversion (Behnke and Robert S. 218).

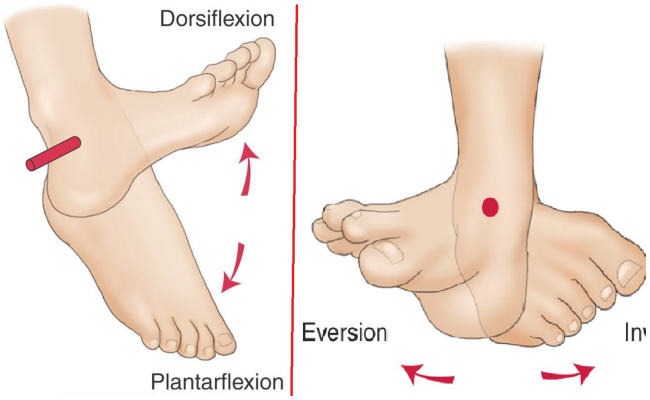

Figure 3. Foot plantar/dorsiflexion and inversion and eversion

Moreover, the ankle joint also has an important shock attenuation mechanism, it is able to reduce impact force while landing (Brizuela, G et al. 505). The arch of the foot has a similar function, acting like a spring on the plantar, decreasing shock transmission to the body (Hogarth, B 210). Footwear science and kinematic studies indicate that human feet have a natural capability to absorb impact, enabling better performance while running and jumping (Brauner, Torsten et al. 191). This research suggested an important consideration for shoe design - to stimulate and maximise barefoot functionality within the basketball footwear design.

Foot sculpting and casting, provided an intimate understanding of foot structures and an actual scaled model of the foot was produced for reference during the design phase (Appendix 1).

Locomotion

Basketball involves physical contact, and specific movements that place pressure on the feet and legs. Because the types of locomotion and manoeuvres on the basketball court are different to other games/sports (Lam Wing Kai et al. 37, 2017) the structure of basketball shoes is distinctive in form to other sports shoes. Compared to football and running footwear, basketball shoes usually require tighter reinforcement for stability, and a higher collar to protect the ankle. Players need stable lateral support during cutting movements, so the forefoot region of basketball shoes is usually wider than other sports shoes.

Analyses of basketball games revealed frequent moves that require acceleration, deceleration, lateral movement and jumping (McClay et al. 205) and literature indicated that design of the footwear needs to respond to high performance demands with cushioning, breathability, protection, traction and overall comfort. For instance,

a basketball player needs to change the direction of their movement frequently on the court, and good traction outsole can help players complete the movement more efficiently and safely.

3.3. Basketball Injuries

Injuries in professional sports are costly to both the athlete and the team. Where the players have rare qualities, difficult to replace, the costs are even more costly. Basketball players are often taller and stronger than players in most other sports (Brauner, Torsten et al. 191), playing basketball requires various types of skills and movements on the court (McClay et al. 205). McClay's study.separated the biomechanics of basketball skills into eleven movements: running; cutting; layup take off; layup landing; starting; stopping; jump shot take off; jump shot landing; vertical jump take off; vertical jump landing; and shuffling. Each of these movements have different kinematic profiles and contribute to different sport injury incidents.

Based on player profiles, data collection revealed that shuffling and layup take off were the actions revealing the largest degree of rearfoot pronation (11.4° and -10.2°), maximum supination, and supination velocity appears on starting moves. Both supination (Figure 4) and pronation (Figure5) findings have implication for overuse injuries, and high velocity would likely increase the strain in the lateral ligament, placing the player at greater risk of injury. Literature (McClay et al. 205) indicates that a foot placed in extreme positions during shuffling and layup should have lateral and heel counter reinforcement to keep the foot in the safety position, thus reducing injury risk.

Figure 4. Left foot supination on court
Figure 5. Right foot pronation on court

Lower extremities of the human body may suffer high impact of six to eight times the total body weight during landing (Fu Weijie and Yu Liu 54). Although basketball is considered a noncontact sport compared to wrestling, athletes in a professional basketball miss 7.6% of games because of injuries (Drakos et al 286).
The types of injuries experienced by basketball players reflect the physical demands of the game, and are defined in sports health research as either acute or overuse injuries. An acute injury is defined as a basketball accident with a sudden, direct cause responsible for the injury. Generally, ankle sprains are the most common type of acute

injury (Figure 6), with NBA statistics identifying lateral ankle sprains as accounting for about 13.2 percent of all injuries (Dracos et. al. 288).

Figure 6. Illustration of ankle sprain

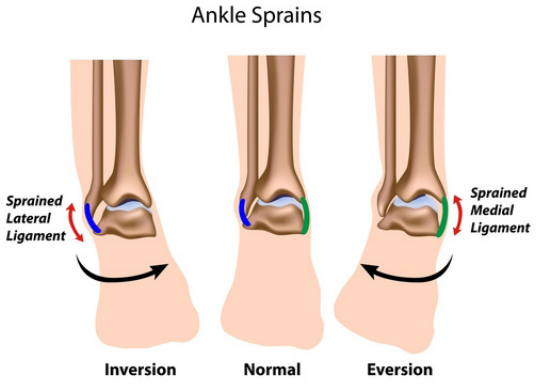

Figure 7. Illustration of patellofemoral inflammation

An overuse injury refers to an athlete experiencing physical discomfort which is present during or after a basketball game. For instance, patellofemoral inflammation (Figure 7) is the most common overuse injury, appearing as 11.9 percent of all injuries (Dracos et al. 288)

Dracos reports that the ankle is the most frequently injured joint of all injuries, and

	All Injuries				Game-Related Injuries				
	Total		Games Missed		Total		Game Related		
Pathology	n	%	n	%	n	%	%	Rate	95% CI[a]
Lateral ankle sprain	1658	13.2	5223	8.8	1066	17.0	64.3	3.2	3.0-3.4
Patellofemoral inflammation	1493	11.9	10 370	17.5	245	3.9	16.4	0.7	0.7-0.8
Lumbar sprain/strain	999	7.9	3933	6.6	361	5.7	36.1	1.1	1.0-1.2
Hamstring strain	413	3.3	1826	3.1	189	3.0	45.8	0.6	0.5-0.7
Adductor strain	394	3.1	1416	2.4	185	2.9	47.0	0.6	0.5-0.6
Knee sprain	392	3.1	4369	7.4	268	4.3	68.4	0.8	0.7-0.9
Foot inflammation	362	2.9	2043	3.5	94	1.5	26.0	0.3	0.2-0.3
Quadriceps contusion	338	2.7	478	0.8	232	3.7	68.6	0.7	0.6-0.8
Knee/patella contusion	321	2.5	690	1.2	213	3.4	66.4	0.6	0.6-0.7
Finger sprain	308	2.4	336	0.6	205	3.3	66.6	0.6	0.5-0.7
Triceps surae strain	259	2.1	2078	3.5	138	2.2	53.3	0.4	0.3-0.5
Leg contusion	227	1.8	316	0.5	157	2.5	69.2	0.5	0.4-0.6

Figure 8. Injury rate by specific pathology

	All Injuries (n, 12 594)				Game-Related Injuries (n, 6287)				
	Total		Games Missed		Total		Game Related		
Structure	n	%	n	%	n	%	%	Rate	95% CI[a]
Ankle	1850	14.7	6838	11.6	1123	17.9	60.7	3.4	3.2-3.6
Lumbar spine	1279	10.2	6729	11.4	481	7.7	37.6	1.5	1.3-1.6
Patella	1266	10.1	8076	13.6	309	4.9	24.4	0.9	0.8-1.0
Knee	1135	9.0	10 737	18.1	501	8.0	44.1	1.5	1.4-1.7
Foot	962	7.6	5992	10.1	374	5.9	38.9	1.1	1.0-1.3
Tibia	954	7.6	5597	9.5	431	6.9	45.2	1.3	1.2-1.4
Femur	905	7.2	3044	5.1	482	7.7	53.3	1.5	1.3-1.6
Hip	781	6.2	2518	4.3	416	6.6	53.3	1.3	1.1-1.4
Hand	571	4.5	2702	4.6	383	6.1	67.1	1.2	1.0-1.3
Face	493	3.9	255	0.4	342	5.4	69.4	1.0	0.9-1.2
Shoulder	466	3.7	1932	3.3	265	4.2	56.9	0.8	0.7-0.9
Eye	351	2.8	359	0.6	237	3.8	67.5	0.7	0.6-0.8
Fingers	298	2.4	696	1.2	195	3.1	65.4	0.6	0.5-0.7

Figure 9. Injury rate by structure

accounts for 14.7 percent of injuries, with lateral ankle sprains the most common (13.2 percent of all injuries) and caused by two main reasons; landing on someone's foot, and rapid change of direction. Patellar tendonitis is the most common overuse injury, caused by intensity of training, jumping performance, and knee joint dynamics, and can lead to pain, inflammation and functional deficit (Cumps E et al. 204).

As part of an attempted solution to these problems, manufacturers provided high-collar support shoes to reduce the risk of ankle sprain. Aa side effect, however. is increased risk of overload injuries due to the higher and tighter ankle collar which restricted ankle joint mobility and associated natural shock attenuation capability, whilst diminishing both running and jumping performance (Brizuela G. et al. 505). A design challenge in basketball footwear is to create shoes with enough ankle support but without reducing motor ability (Brauner and Torsten et al. 191).

Follow this insight, one of the goals is to explore concepts for effective adjustable ankle collar designs that could achieve this aim while being comfortable and non-restricting.

3.4. Player Position

The player's position is an important issue related to the type and frequency of injury rate (Henry et al. 16). The figure below shows guard players suffer mostly lower extremity injuries, whereas forwards suffer a large number of upper extremity injuries, and centers usually have a combination of injuries.

	Total injuries	Percentage of injuries
Guards	248	
Back		11
Knee		48
Foot		12
Forwards	235	
Head		17
Finger		14
Hip		6
Centers	93	
Head		23
Knee		17
Ankle		14
Foot		9

Figure 10. Relationship of type of injury and player position(Henry et al. 17)

A basketball game has five positions on court: point guard (PG), shooting guard (SG), small forward (SF), power forward (PF), and the centre (C) (Rose and Lee H. 47). The different positions have their own responsibilities during the game, with different physical requires and skills (Brauner and Torsten et al 191).

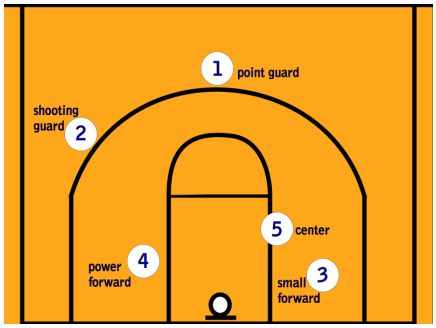

Figure 11. Basketball piosition on court

The descriptions in the three paragraphs that follow are summarised from The Basketball Handbook (Rose and Lee H) and Braune et al. 191-198. The point guard is typically the leader of the team when on the court. This position requires substantial ball handling skills and the ability to guide the team during a game. The shooting guard is often the best shooter with capability to shoot from longer distances. Generally, both point and shooting guards also have good ball-handling skills. Guard player are usually not required to be very tall compared to players in other positions, because their emphasis is more on agility and speed on the court.

Figure 12. Pre- NBA point guard Steve Nash

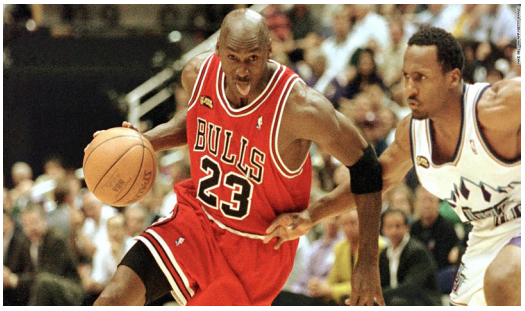

Figure 13. NBA shooting guard Michael Jordan

The small forward often has an aggressive approach to the basket when handling the ball and is primarily responsible for scoring. Players in the small forward position are usually versatile, and require a good combination of physicality and skill.

Figure 14. NBA small forward Lebron James

Figure 15. Pre-NBA power forward Karl Malone

The power forward and the centre are usually called "low post" players, who play with their back to the basket, often needed to protect the team's rebounds and block shots, or to get passes to take inside shots. Normally they are the tallest and strongest players in the team, because inside players require more body contact.

Figure 16. Pre- NBA centre Houston Rockets Yao Ming

Estimates show that the type of injury received is related to position played, Guards are usually smaller but with agility and speed, they often perform a lot of fast direction changing and they run the farthest distance of all positions on the court (Brauner and Torsten et al 191). Because of the way they play, guard players suffer the most from lower extremity injuries (Henry et.al 17).

Effectiveness of shoes design is related most to lower extremity injuries.
Different hardness of midsole, for example, will affect both the knee and foot plantar, and the height of the ankle collar directly affects the ankle joint. These factors influence acute and overuse injuries of the lower extremities. It is apparent that players in the guard position have the greatest requirement for shoes to alleviate lower extremity injuries, and this is a major focus for this design research project.

Brauner and Torsten surveyed players for what shoe characteristics they demanded. The findings showed differences in player usage and functional preference according to the position in which they played (Brauner and Torsten et al 191).
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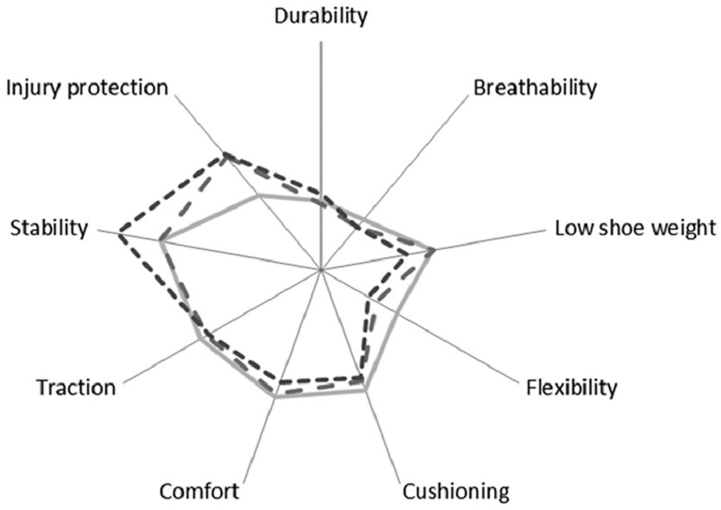

Figure 17. Shoe preference by playing position

Guards, forwards and centres shared similar performance requirements for traction, comfort and cushioning (Brauner and Torsten et al 195). All players in these positions face high impact running and landing. In the context of overuse injury, comfort cushioning helps to reduce impact power and prevent injuries.

Guards and centres have, however, additional special requirements for shoe characteristics. Guards usually require speed and agility and put more emphasis on low-weight and more flexible shoes, while centre players require strength and strong leaping ability, and preferred shoes with high stability and injury protection (Brauner and Torsten et al 197).

The differences identified in this study provide insight into how a basketball shoe may be designed for a specific player positions.

3.5. Elements of Basketball Shoes

Sports shoes are designed with different shapes and structures compared to fashion shoes, and emphasise more of the function, with a more complex manufacturing process. The specific functional demands of basketball shoes, have clear differences to running shoes or any other sports shoes. The, basketball shoe commonly requires ankle protection and better lateral stability (Frederick EC and Himmelsbach JA). Within the design development, some elements of the structure may be diminished or increased, but this chapter is a guide to show the basic shoe parts needed and explains the purpose of these components. Following information base on the book (Sneakers: The Complete Collectors' Guide) and journal articles (Frederick and Wojcieszak 2005).

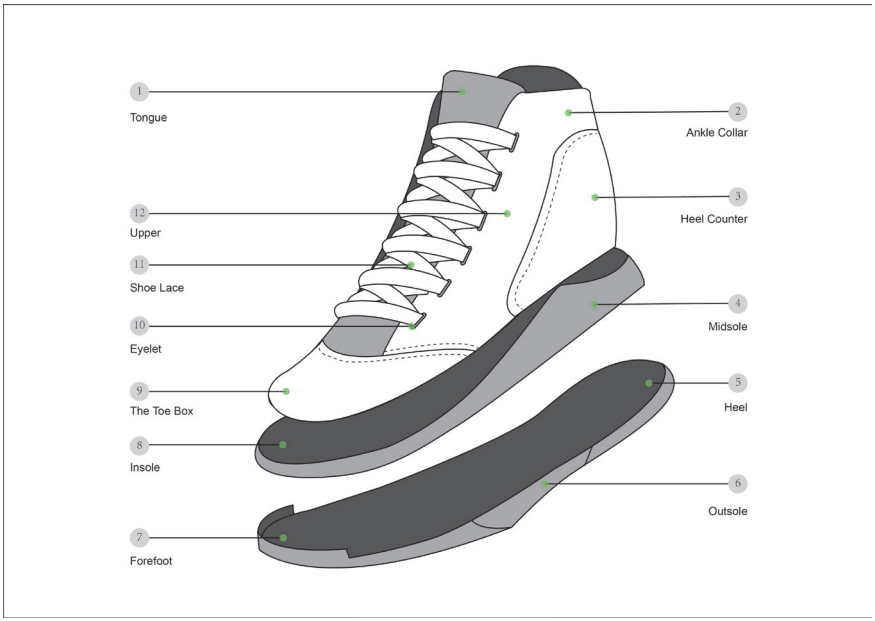

Figure 18. Element of Shoe

1. Tongue: The tongue is the component between the shoelace and the foot, named because its shape is slightly like a tongue. The tongue is generally considered reinforcement and contributing to custom fit.

2. Ankle collar: The ankle collar aims for comfort and support of the ankle, and is usually filled with soft foam to fit the ankle. The terms high-cut and low-cut are used to describe the height of the ankle collar.

3. Heel counter: The heel counter is reinforced or padded for heel support, and provides stability for the heel.

4. Midsole: This is located between the toe and heel areas, on the sole of the shoe, and its function is to absorb pressure shocks while landing, and to provide medial and lateral stability in specific basketball movements. The midsole is where the majority of shoe technology is applied.

5. Heel: At the rear part of the shoe, heel cushioning is necessary.

6. Outersole: The layer of sole that contacts the ground and is often made from a hard rubber material. Basketball shoes require good traction while moving, so different brands usually design different patterns on the outersole and use various hardness qualities of rubber for this purpose.

7. Forefoot: This section at the front of the shoe, responds to acceleration flexibility allows for easy movement.

8. Insole: This is the layer that contacts the foot plantar, and Its role is related to shoe comfort, custom fit, and cushioning for the foot.

9. The toe box: This area provides extra protection to the toes, using firm materials.

10. Eyelet: Also called eyestays, these are used for either speed lacing or extra reinforcement.

11. Shoe lace: A closure system for the shoe, mainly for the purpose of stability.

12. Upper: The upper surface of the shoe affords protection, stability and breathability.

Using a basketball specific testing protocol (Lam Wing Kai, T et al. 151), Lam Wing Kai and his team found that a basketball shoe has special functional requirements for movement, and certain regions of the shoe have a significant effect on comfort and fit. They set up a method to estimate fit and comfort perception. Nineteen university basketball players participated in this testing, finishing a sequence of acceleration, deceleration, lateral shuffling, lay-up, backward running, jumping and landing movements (Figure 19), named the 'basketball specific course (BSC)'.

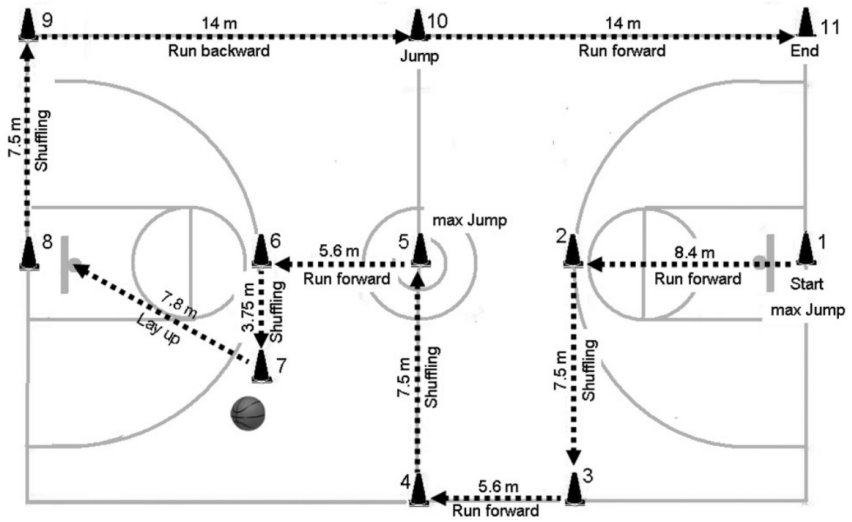

Figure 19. Illustration of the basketball specific course(BSC)

Six different high-collar basketball shoes were tested, with a high collar being the only common feature among them. Five elements: heel cushioning, forefoot cushioning, collar, medial-lateral control and overall comfort, showed significant effects on the players' perceptions of shoe comfort. Shoe length, heel and forefoot width, and collar height were the key elements in perceptions of shoe fit.

According to findings in the BSC protocol, a clear direction for the development of comfortable basketball shoes became evident. Further study of materials, hardness of cushioning, and manufacturing process, has the potential to improve these five elements of shoe comfort and performance.

3.6. Design Precedents

1960s, Converse All Star (Chuck Taylor)

Converse All Star is a shoe so iconic that it became a better known symbol for basketball than the ball itself, and its history tracks back to 1917 (Coles Jason, 10). When basketball rose in popularity in the USA, Converse released the All Star shoe to meet the growing demand for a suitable shoe. In 1921, Converse followed basketball player Chuck Taylor's recommendations, based on his playing experiences, and improved the shoe which modified the width of the shoe forefoot, for the purpose of stability. In 1934 Taylor became the first person to have a signature shoe and the shoe became famously known as 'Chuck'.

Figure 20. Converse All Star

Converse All Star dominated the sports footwear world for over thirty years from 1936 to 1968, from when it became the official sports shoe of Team USA in 1936 Olympic Games (Coles Jason, 10). The All Star shoe held 90 per cent of the college and professional basketball player shoe market in 1969. In the early 1970s its market share was impacted by Adidas and Nike, and in 1979 Tree Rollins was the last NBA player to wear these shoes in a game (Coles Jason, 12)

With design, material and technological developments, canvas and rubber shoes declined in popularity as they were no longer able to satisfy the functional or aesthetic demands of the athlete. In particular, there was insufficient cushioning and sole traction to offer players a good experience. Converse All Star then made the shift from functional basketball shoe to casual shoe and it exists today in the fashion footwear market.

1970s, Puma Clyde

While Converse All Star began to be a rare sight on court in the 1970s, a variety of brands and new shoes was rising rapidly. The Puma Clyde shoe was born in that period. Named after New York Knicks legendary point guard Walt “Clyde” Frazier, Puma Clyde became the first basketball shoe to be named after a player, and its

success relied on Walt Frazier being the first player to bring style and fashion to the court. In aesthetic aspects, Puma used the streamlined, smooth form of the shoe to reflect the movement of Walt Frazier, highly agile, fast and ornamental. "Walt Frazier became the definition of New York style"(Jason Coles 51), with the design of Puma Clyde was perfectly matched to Frazier. A classic guard position basketball shoe, the design language of Puma Clyde highlights another consideration for the design criteria.

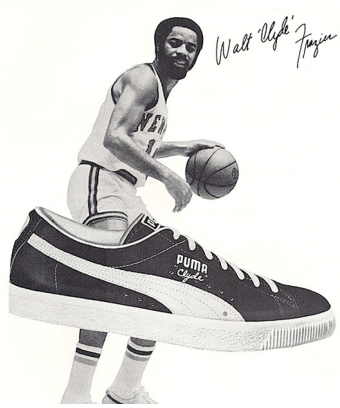

Figure 21. Walt 'Clyde' Frazier and Puma Clyde basket shoe

Puma Clyde, with suede upper and a wider sole for better stability, became one of the most popular shoes in the NBA of the 1970s, Puma sold over a million pairs of between 1972 to 1980. In the modern sports field, Puma Clyde, like many other basketball shoes of that era, eventually found its way off the court and onto the streets, now being an essential part of the lifestyle sneaker culture.

1980s, Air Jordan 1

The series “Air Jordan”, named after NBA player Michael Jordan, continued to include appearance as an important part of shoe design. When the first Air Jordan was released in April 1985, it became a phenomenon that changed basketball footwear forever (Jason Coles 78). Air Jordan was focused on being stylish and matched with Jordan's unique playing style. Not only did it have a great appearance, it also had well developed ankle support and cushioning to deliver the best basketball shoe performance ever. By the end of the 1985, Nike had sold Jordan shoes worth over 100 million US dollars.

During the late 1980s, a further three pairs of Jordan shoes were released. These shoes dominated the basketball court and had a significant effect on the future of basketball shoe design.

Figure 22. Air jordan 1

Air Jordan XI 1996

In the 1990s, basketball became the fastest growing sport in the United States of America, and the generation of NBA stars also meant there was an explosion of diversity in the next wave of basketball shoes.

Figure 23. Air jordan 11

Air Jordan XI, was born while Jordan was winning his 4th NBA championship in 1996 (Sneakers 75). Air Jordan XI used a mesh upper of the shoe, to make the Air Jordan XI lighter and more breathable than past shoes. Patent leather has been used all around the shoe which provided extra lateral support and protection for the toe, moreover, it delivered great style for the fashion arena. Other revelations came with the use of a carbon fibre shank in the translucent outsole, offering torsional rigidity and responsiveness which gave the shoe better an improved ability to prevent foot and shoe over-twisting on the court. This translucent outsole visually communicated to show the carbon fibre shed (Sneakers 75). The method of using a stiff medial shank kept the foot in the correct position, reducing the risk of injury was an important consideration for the design criteria in my project.

Reebok Shaqnosis 1996

New stars stepped onto the scene, and with them new basketball shoes were developed. As one of the greatest centres in NBA history, Shaquille O'Neal really succeeded in the shoe market. Reebok released Reebok Shaqnosis in 1996, using Reebok's 'InstaPump' technology to provide great rear foot cushioning for a player weighing 325 pounds (Jason Coles 102).

Figure 24. Reebok Shaqnosis

Nike Air Foamposite 1997

NBA player Penny Hardaway got his first signature shoe in 1997. According to the book (Sneakers 79), the Nike Air Foamposite One is the most spectacular and most unique basketball shoes the world has ever seen, part of Nike's innovative and futuristic

approach in the 1990s. It combined 'Foamposite ' technology and synthetic leather, and provided extreme upper support and lateral movement .

Figure 25. Nike Foamposite One

Nike's Luna Hyperdunk 2012

Nikes Luna are one the most famous examples of midsole technology with a soft, yet responsive foundation. It improved past models, with additional foam in the key areas of forefoot and rearfoot to enhance lateral stability and durability. Developments in the ankle collar area saw a synthetic heel clip enhance lockdown and tighter ankle support. Moreover, a high-wrapping lateral outrigger provided reinforcement for hard cutting and extra lateral support for players, an important design consideration and criterion for this project. (Solecollector.com)

Figure 26. Nike Luna Hyperdunk 2012

Adidas's Crazy Explosive 2017

Adidas developed a basketball shoe that used a knitted textile on the entire upper shoe, reducing weight while further increasing breathability, stretch and durability. Hot melt thermoplastic polyurethane (TPU) wrapped around the lower upper to enhance lateral stability, with a triangle clip in the side of the forefoot to deliver extra stability. (Sneakernews.com)

Figure 27. Adidas Crazy Explosive 2017 Primeknit

Summary of Design Precedents

At the turn of the millennium, as basketball made higher physical demands on the player, with increased body contact, brands started to develop new technologies and manufacturing processes in every aspect of basketball footwear, to pursue better performance and alleviate injuries. In order to achieve lighter, more breathable and flexible uppers, synthetic mesh and hot melt technology were developed from 2008,. Since 2015, 3D weaving or knitted uppers are gradually substituting the once popular synthetic mesh to become a mainstream textile for basketball footwear uppers. With developments in innovative technology, different densities and materials for the midsole were being produced, with the aim of absorbing more landing impact and allowing faster power reactions,

On-Court as well as off-court, is one of the most important concepts of basketball footwear design today. "Sneaker culture is no longer underground" (Kawamura, Yuniya 45). Customers will buy a pair of basketball shoes although they never play basketball. ‘Fashion meets performance’ is a trend of today's basketball footwear design.

Following the trends in materials and fashionable features are important aspects for the design consideration

3.6.1. Technology and Material Development.

The higher physical requirements of the modern basketball game mean that basketball shoes need an improved ability to protect the player and assist with athletic performance, requiring ongoing research into innovative textile development into the upper and midsole area.

Midsole Technology

The midsole is the part of the shoe that provides the most cushioning effect to the body. It absorbs impact during landing actives (Songning Zhang and Kurt Clower et al. 15). The shoe's cushioning is achieved through three different aspects: materials, space and structure. The density and hardness of the materials (foam) is specified to provide the desired cushioning. Space (in the form of gas filled cushions) controls deceleration. Structure provides physical cushioning that distributes impact and provides support to the foot.

The materials used for midsole cushioning is made from rubber, ethylene-vinyl acetate (EVA), phylon (a specialised EVA material) and polyurethane (PU), and the combination of these materials to make up the varying densities and profiles. Based on these materials, brands using various combinations and compression technologies achieve the right firmness and resilience for the intended performative requirement.

Space cushioning was invented by Nike in 1979. Pressurised gas in a hidden sole pocket in a basketball shoe, to absorb shock power, was first shown by Nike in the Air Force 1 shoe (Sneakers 28). Within the generation development, there were various types of Air sole, including 'Air Zoom' and 'Air Max' (Figure 28, 29).

Figure 28. Family of Air Zoom

Figure 29. Evolution of visible air (Air Max)

Structure cushioning, also called physical cushioning, is a structure designed to absorb the vibration and impact on the foot during the game, but it is less widely used in basketball shoes. Li-Ning, a Chinese manufacturer, created technologies called 'Bow' and 'Cross bow' (figure 30 and 31) which are examples of structural cushioning. Their method stimulated the structure of the arch and string, 'Bow' provided full cushioning and support and 'Cross Bow' units are placed in specific locations for regional cushioning (Tech.Lining). Structural cushioning technology, Li-Ning 'Bow' is used in contemporary basketball footwear products.

Figure 30. Li-ning Bow

Figure 31. Cross Bow Unit

Manufacturers often combine different cushioning methods to provide optimal shock absorption effects.

Upper Technology

In comparison to the mid sole development, upper-shoe technology has experienced even greater innovation in the development processes. Trends in material innovation have appeared across the spectrum of basketball shoes available. The following Table (Table 1) list out the main materials used on the upper shoe, along with the advantages and disadvantages.

Material	Period	Advantages	Disadvantages
Canvas	1960-1970	Durable	Heavy Lower foot support
Leather	1970-1980	Fashionable Good quality	Heavy High cost Not flexible
Synthetic leather	1990s	Cost less Fashionable	Heavy Not breathable Not flexible
Synthetic mesh and fabric	Early 2000-now	Light weight Flexible Breathable Cost less	Not environment friendly.
Engineered knit and woven fabric	After 2015-now	Light Weight Flexible Breathable Less materials and manufacture phases	Not durable, easy get scratch and broken Lower foot support

Table 1. Pro and con of exist upper materials in basketball design

Currently, light weight, flexible breathable fabrics are the main specification for upper material applications. Compared to synthetic mash and fabric, knitting and woven fabric uppers can provide better flexibility and breathability, and can mould to the foot surface like another layer of skin. However, the softness of the knitted and woven fabric uppers means the shoe does not always offer enough structural support in a basketball game. Combining soft cushioning with firmer structural materials in the toe box, lateral side and heel may provide performance benefits for players, giving greater control and a softer impact.

3.7. Summary of research context

The contextual review identified key consideration and criteria for redesign of a modern basketball identifying the design should:

- stimulate and maximise barefoot functionality within the basketball footwear design.
- provide a stable lateral support during cutting movements undertaken when playing.
- support frequent player acceleration, deceleration, lateral movement and jumping

- through its materiality provide breathability, protection, traction and overall comfort
- respond to high performance demands with cushioning
-have lateral and heel counter reinforcement to keep the foot in the safety position, reducing injury risk.
-have enough ankle support but without reducing motor ability

Guards, forwards and centres share similar performance requirements for traction, comfort and cushioning, and guards usually place emphasis on low-weight and more flexible shoes, Overall, heel cushioning, forefoot cushioning, collar, medial-lateral control and overall comfort, impact on players perceptions of shoe comfort.Trends in materials and fashionable features are important aspects for the design consideration.

4.0. Primary Research

4.1. Lead User Interviews

The target user in this project is the professional basketball player. To supplement and expand the research context, I interviewed and watched Wellington Saints, professional basketball players in training. A photographic and video record was permitted, to observe shoe function and foot position in different locomotion activities. This observation of user behaviour under live conditions (Figures 32 and 33) informed my design process and the synthesis of my contextual review.
Three Saints players participated in the interview after training on one occasion and

Figure 32. Position of leg and foot while jump shot

Figure 33. Foot position while changing direction

another two players from other teams participated on a different date. Of the five players, three were guards and the others played forward.

The purpose of the interview was to elicit user experience and aspirations regarding basketball footwear that "helps to uncover the social value system and emotional responses to products" (Bruseberg Anne and Deana MacDonagh-Philip 441). The questionnaire is attached in appendix 2.

Comparing player responses to the survey questions, with my contextual review, revealed that many of the responses were consistent with the current research and literature on this topic. A difference in findings between my questionnaire and the

literature reviewed focused on the forefront of the shoe. All five players emphasised that solid rebounding support (firmness and resilience) is the most important characteristic of the basketball shoe, to get quick respond to impact while accelerating during the game.

Consistent with the literature, three players mentioned shoe traction and stability as an important feature. Three players thought the forefoot received the most pressure in the game, while the other two stated heel and ankle areas received the most pressure – this may have reflected a difference in their playing styles that I was unable to observe. All players thought a high collar basketball shoe made them feel safe from ankle injury but reduced flexibility and mobility, giving an uncomfortable feeling but better protection in a rigorous game. Three guard players said that the low-cut shoe gave them a better experience, and one forward player mentioned their shoe choice usually depended on the level of the game.

Three design considerations, therefore, arose from the interviews. The first is confirmation that stability and traction are needed in the shoe. Secondly, a consideration that greater focus on the forefront of the shoe would be desirable, and a third consideration of whether the collar could be adjustable to respond to player preference.

4.2. Practical Participation

To give myself real experiences of professional basketball playing, I joined the Wellington Basketball Academy to train for two months with Kenny McFadden (former professional player in the Wellington Saints). I learned basic movements and how to improve my footwork in standard training and in a scrimmage game after training. I recorded several videos of myself during training, to observe movements and collect data. The videos allowed me to observe foot position and movement during the vertical jump take-off and landing, lateral shuffling, acceleration and deceleration, and cutting movements referred to in the literature. See figure 34.

Figure 34. Self training video record

I found that the torsion of foot mostly happened in cutting movements and lateral shuffling. The forefoot region experienced the most impact during acceleration and deceleration, while the heel region received most impact through the vertical jump take off. Additionally, my forefoot felt more impact pressure than the heel area of the foot. This finding gave more impetus to investigate the design considerations identified in the interviews.

4.3. User Trial

"Under Armour Stephen Curry 2 Low", basketball shoes (see Figure 35) were used in the trial. The shoe was selected as it has been a major driver in the market over the last three years and it is a typical guard position basketball shoe.

Figure 35. Trial Shoes: "Under Armour Stephen Curry 2 Low"

I wore it for two months during basketball training sessions. Frequency of usage was generally four times a week for two hours each time. I recorded changes to it every fortnight, as part of data collection about how the shoe and foot were affected while playing basketball. Recorded data included: shoe components, fit and comfort, cushioning, traction control, fashion style, materials, and aspects of durability. The trial process provided insight into the user experience, the brand's design method and philosophy and how design language translated into specific shoe characteristics.

Fit and comfort

I used US shoe size 9 in the trial, rather than the preferred 8.5 size of my usual on-court shoes, because the toe box of the shoe was very tight and narrow. Even so, the shoe was uncomfortable while playing, and my right large toe remained bruised after two weeks of playing (Figure 36). The midsole of the shoe extends up the lateral side of the forefoot with the aim of providing additional support during lateral movement. However, this feature also limited mobility and moving space and caused injury.

The injury to my toe made me wonder whether the toe box was wide enough for me, or whether the midsole extended too far up the side of the toe (Figure 37). However, none of the players interviewed or the literature mentioned this, I assumed it was my personal issue.

Figure 36. Bruised right foot thumb

Figure 37. Toe box and extend midsole

The upper uses breathable and flexible material, that adapted well to the foot, and the toe area didn't feel any uncomfortable while running or jumping. An additional synthetic layer found at the toe and along the forefoot provided extra protection to toes.

Speedform technology, shown in figure 38, is used for the heel region, a combination of thin tensile fabric with a TPU (Thermal polyurethane) heel counter (see Chapter 3.5). The fabric provides great stretch properties that conform well to the foot, especially at the ankle area. This change is a nice example of a reduction in materials while still retaining its containment and support abilities. These features are shown figure 39. The collar of the shoe is an extremely low-cut basketball shoe (Figure 40 show a high collar shoe for comparison), and the TPU heel counter doesn't extend up high enough to give the heel full lockdown. With no additional interior filling to lockdown the achilles ligament, the heel fit felt very slippery, and unsafe in full-speed game situations.

Figure 38. Introduction of UA SpeedForm

Figure 39. Highlight of Speedform area

Figure 40. Collar comparison

The lacing system used is a notched eyelet lacing setup, shown in figure 41. Through the first four eyelets, it laces up very tight and forefoot lockdown is fine. However, the crucial top eyelets for heel and ankle stability can’t be pulled tight enough because the fabric around the ankle area is too stretchy and doesn't stay tight.

*Figure 41. D*etail of notched eyelet lacing setup

A consideration for my design could include an integrated closure system and collar design to ensure the ankle is supported well during the game.

Cushioning

In the "Curry 2 Low", full length Charged Foam (UA footwear midsole cushioning technology) is used for the midsole to provide responsiveness on court whilst absorbing shock impact. This feature was consistent with my interview findings where almost every player emphasized that a firm responsive sole was critically important in professional level basketball. According to the data retrieved from reverse engineering of a basketball shoe, the forefoot and rear foot regions of the sole are split into two different hardness foams. Thinner and firmer hardness foam (Figure 42) is used in the forefoot to provide quick rebounding reaction when accelerating and changing direction. Softer hardness and thicker foam (figure 43) in the rear foot region gives better heel cushioning while landing, to reduce impact power and diminish overuse injuries.
The design consideration which arose from this section was to find the standard hardness range for basketball midsole materials and use materials (foams) of appropriate thickness and hardness for the sole in my design project.

Figure 42. Thickness measurement of forefoot region midsole foam

Figure 43. Thickness measurement of heel region midsole foam

Traction

For the outsole pattern, a variation of an organic herringbone pattern (Figure 44) is used for the "Curry 2 Low" basketball shoe that I examined in the user trial. This pattern appears with deep grooves and thinner blades that radiate from the center to the outer edge of the shoe sole, offering the player traction in all directions with any movement. For a player in a guard position, the "Curry 2 Low" shoe has considered the player movement profile in all respects. The outsole extends higher up the shoe in both the forefoot and rear foot regions as highlighted in figures 45. Regarding the guard locomotion features, the extended outsole provides additional traction when players use a lateral cut and quick direction changes on the court.

Figure 44. "Curry 2 Low" outsole pattern

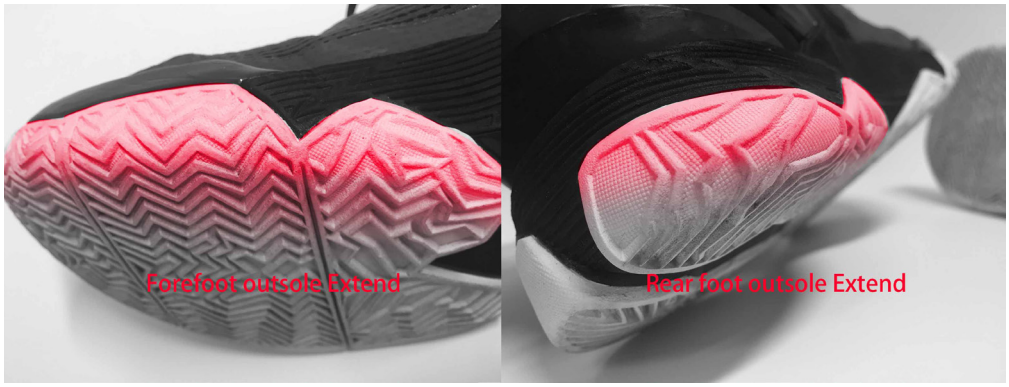

Figure 45. Outsole extend on fore forefoot and rear foot region

The herringbone outsole pattern is recognised as having great efficiency of traction and a redesign that incorporates outsole traction features should be considered.
Materials and Durability

In the "Curry 2 Low" shoe, double side synthetic mesh upper, wrapped around the forefoot and tongue area, gives flexibility and breathability. To the touch, the inner layer textile is softer and smoother than the outer (Figure 46), giving additional comfort with long time wear, the only adverse issue being that the outer textile may become easily scratched (Figure 47). The Speedform is used on the heel section, and while it offers little ankle support, it allows free movement.

Figure 46. Outer and inner side mesh fabrics of "Curry low 2"

Figure 47. Scratch on outer mesh

The use of different materials on each side of the upper is to provide both comfort and durability, and they are often synthetic materials. As my design intent is to design a basketball shoe for professional players I will focus on using more natural, breathable materials for comfort.

4.4. Reverse Engineering

Reverse engineering is used to inform a redesign process, dissembling and analysing the component parts and their assembly to fully understand a products construction (Kevin N and Kristin L 226). In this research project, I used data about shoe structure, methods of manufacture, and the sequence of processes to build a shoe, combined with reverse engineering.

Three different shoes (Figure 48, 49 and 50) were reverse engineered - two of them low ankle support basketball shoes and other had high ankle support. The disassembly progressed systematically, labelling each component as it was removed and is presented in a knolling format below (Figure 51, 52 and 53). Throughout the disassembly, notes were made on the general assembly and construction of the shoe.

Figure 48. Nike Lebron 9

Figure 49. Nike KD4

Figure 50. Under Armour Stephen Curry 2 low

Figure 51. Knolling of Nike Lebron 9

Figure 52. Knolling of Nike KD 4

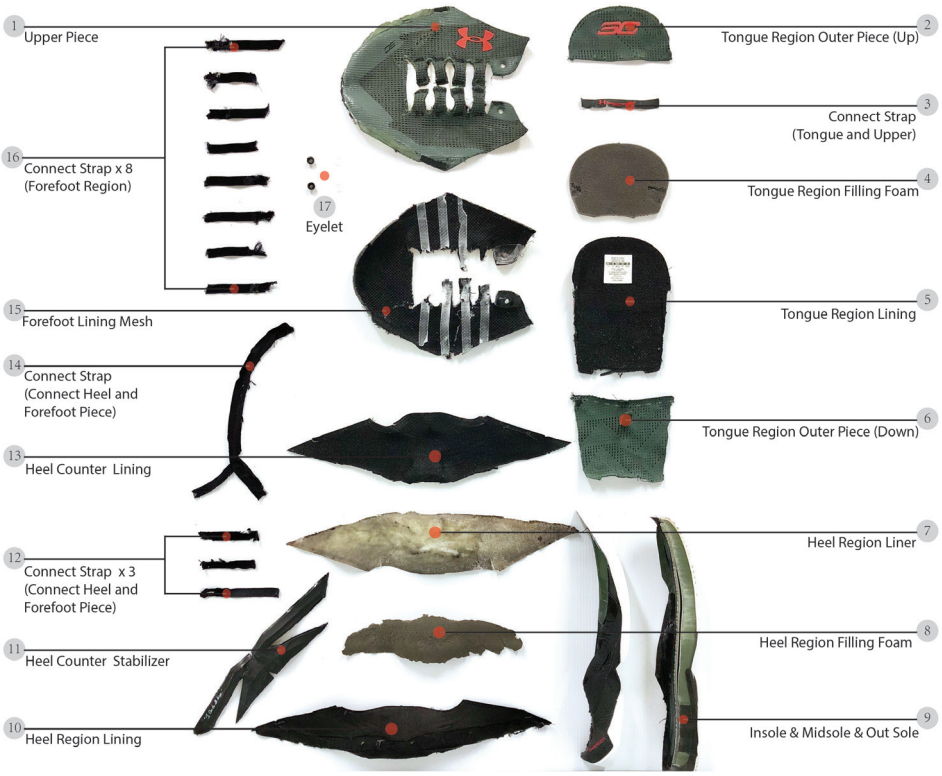

Figure 53. : Knolling of Under Amor Stephen Curry 2 low

All three shoes were marketed between 2011-2016, and no significant manufacturing or structural differences were shown in this study. The findings are presented in a table format (Table 2).

Shoe	Release Time	Number of Main Items	Similarity	Difference
Nike Lebron 9	2011	25	·Reinforcement on toe box and heel counter ·Filling foam in tongue and heel counter ·Different cushioning effect on forefoot and heel. ·Synthetic material upper Mid-foot stiff shank	· Nike Zoom Air space cushioning unit on forefoot ·Extra filling pad in collar part

Nike KD4	2012	20		· Nike Zoom Air space cushioning unit on forefoot. ·Stabilizing strap
Under Amor Stephen Curry 2 low	2016	17		·Connected insole and midsole

Table 2. Findings of reverse envgineering

The shoes that I reverse engineered were NBA star signature shoes, specifically designed for the top professional players. All had reinforcement and filling pads in specific areas, although not always the same areas. All had cushioning effects on forefoot and heel, but none were identical, or with the same level of resilience. In common, all shoes had a mid-foot stiff shank. My design consideration will include these features.

4.5. Summary of primary research

Exploring the relationship between the foot and the shoe is one of the key points in this research project, and part of the primary data collection included how the shoe and foot were affected during the game of basketball.

Lead user interviews reinforced the findings of the literature, A typical guard player needs a shoe that provides traction, stability and cushioning to improve comfort and athletic performance. Player participation confirmed that the herringbone patterned outsole of the "Curry 2 Low", provided significant traction on court, with minimal likelihood of skidding during play. Extending the outsole in the toe area and in the forefoot provided extra lateral traction and stability creating greater efficacy with cutting and shuffling. As the Herringbone outsole pattern has been proven to provided supreme traction, I formed the view that extending and using a herringbone pattern on the outsole would give my design the necessary traction., I considered at most an offset redesign of herringbone pattern for my further design process.

I identified the possibility of varying the hardness of the midsole foam deployed in forefoot and heel as a design consideration, User interviews suggested a preference for greater resilience/firmness in parts of the shoe, and I disassembled my user trial shoe, using reverse engineering, which allowed me to consider different performing foams in different areas. Hardness of midsole foam is critical in cushioning criteria, harder (Shore A 52-56) for forefoot offers quick responsive while acceleration and softer (Shore A 43-46) on heel gives comfort cushioning. Cushioning in the midsole is particularly important. Reveres engineering indicated that a stiff mid-foot shank is a design feature that reduces the torsion I experienced when playing.

The basketball shoe, that I examined in user trial, the "Curry 2 Low" satisfied most of the lead player requirements but the lower collar, while it offered free ankle space that maximise the mobility, offered less than optimal support. and this suggested to me that a redesign of the collar, to allow it to be pulled up or pushed down, could improve the tailoring of the shoe to individual player preferences. Designing a collar that can provide enough ankle protection but without reducing athlete performance will provide performance benefits.

Player perspectives and my user trial suggested using reinforcements and filling foams in specific regions of the shoe, the heel and the toe, to have significant effect on the shoe's stability and protection is also a design consideration.

In the literature the outrigger is shown to delivers a wider forefoot and also gives extra lateral support which can prevent players from turning their ankle (pronation of the foot) when they make the extreme lateral movements - an issue of stability that lead players identified as important.

5.0. Design Considerations

Design Aim:

To Design a basketball shoe for the guard position, integrating performance, injury prevention features and an innovative aesthetic style.

Design Considerations - Function and usability

Eight design considerations were developed:

1. The design accommodates customisation of the collar by the player to achieve their specific requirement.
2. A flexible upper that achieves comfort thoughout continuous foot bending.
3. An innovative closure system simplifies putting shoe on and off.
4. Mid-foot stiff shank offers tensional rigidity and responsiveness while extreme situation.
5. Foot support and protection in toe box, lateral side and heel region to keep foot in the safe place while movements.
6. Regional cushioning (Shore A 52-56 for forefoot, shore A 43-46 for rear foot) to provide located cushion effect, to achieve different requiems for specific region.
7. Redesigned herringbone outsole pattern provided the high traction while running and jump take off, reduce the risk of falling down and achieve quicker acceleration and deceleration.
8. Extend outsole pattern and high-wrapping lateral outrigger both achieve stable lateral movement ability while cutting and jumping.

Design Consideration - Aesthetic

While design considerations reflected the findings from the overall research context, the aesthetic design is intended to communicate the innovative performance characteristics of the final product. The perceived performance qualities of the guard position included: streamlining, dynamic performance, drama and sophisticated high technology materials and structures. Particular attention was paid to the style of the collar, the shoe upper texture, and development of an innovative shoe closure system.

6.0. Design Methodology

The design process has involved continuous feedback loop between research, concept gathering, concept exploring and prototype development. This section details methods used in designing the basketball shoe and explains why these were the most suited in this research project.

6.1. Concept Generation

The methods I used to generate concepts include mind mapping, set up visual references board and thumbnail drawing. A mind map showing early considerations of my design direction and is displayed in figure 54.

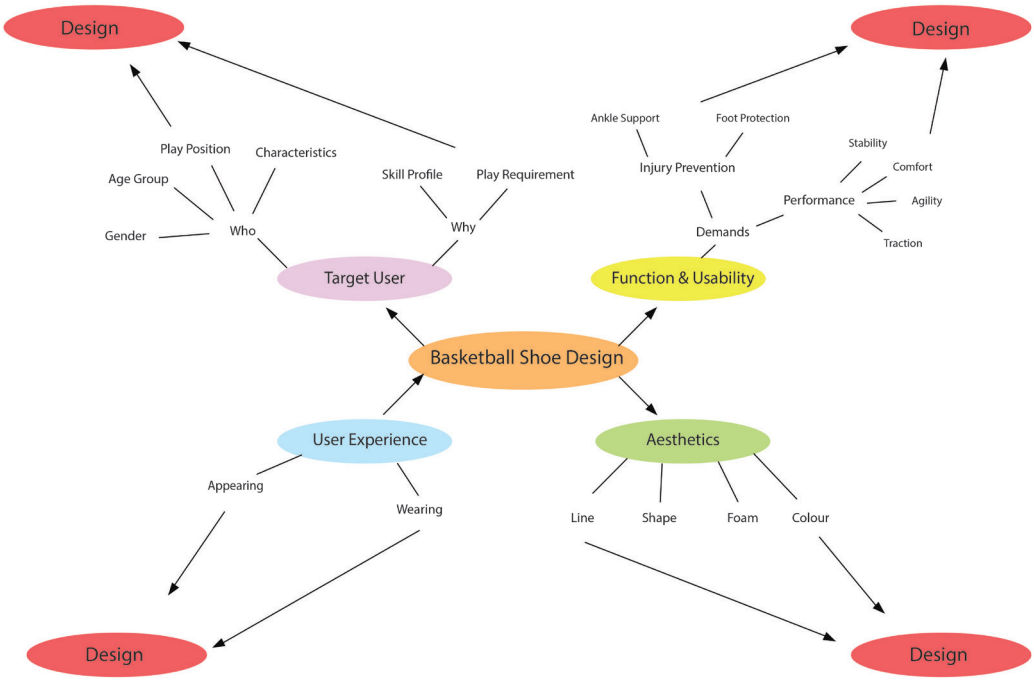

Figure 54. Mind map

The aim of build up visual references board is to inspired concepts and represent aesthetic direction, images were collected in particular themes that realted to this research, and are attached as following figures (next page).

Figure 55. Animal motion inspiration

Figure 56. Athletic performance inspiration

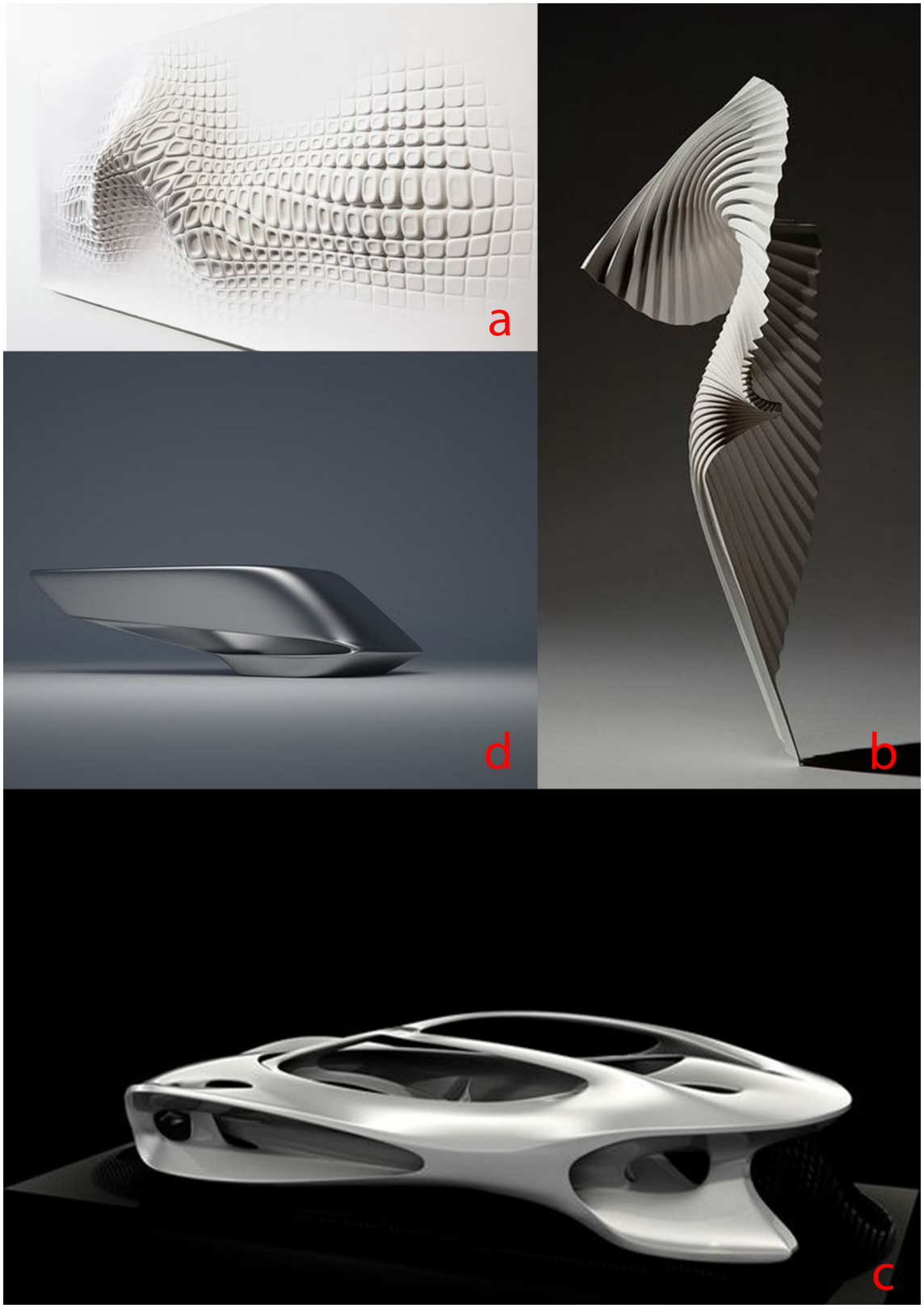

Figure 57. Modern art inspiration

Thumbnail sketches of early design stages explored multiple concepts which were later adapted to schematic design and design details, presented through side views to deliver detailed visual communication. Areas of interest to further develop relating to aesthetic and function are highlighted and annotated (Figures 58, 59 and 60). Further concept sketches are attached in append 3.

Early visualisation included a focus on the collar design that developed throughout the project. The circled design in figure 58 resented a collar that was intended to provided enough support to the ankle while allowing it to move freely. As a key part of my design thinking, this idea has helped direct the entire design process and become one of the main features for the design development. The final design focusses on the ankle collar being constructed from a textile with stretch and flexible properties.

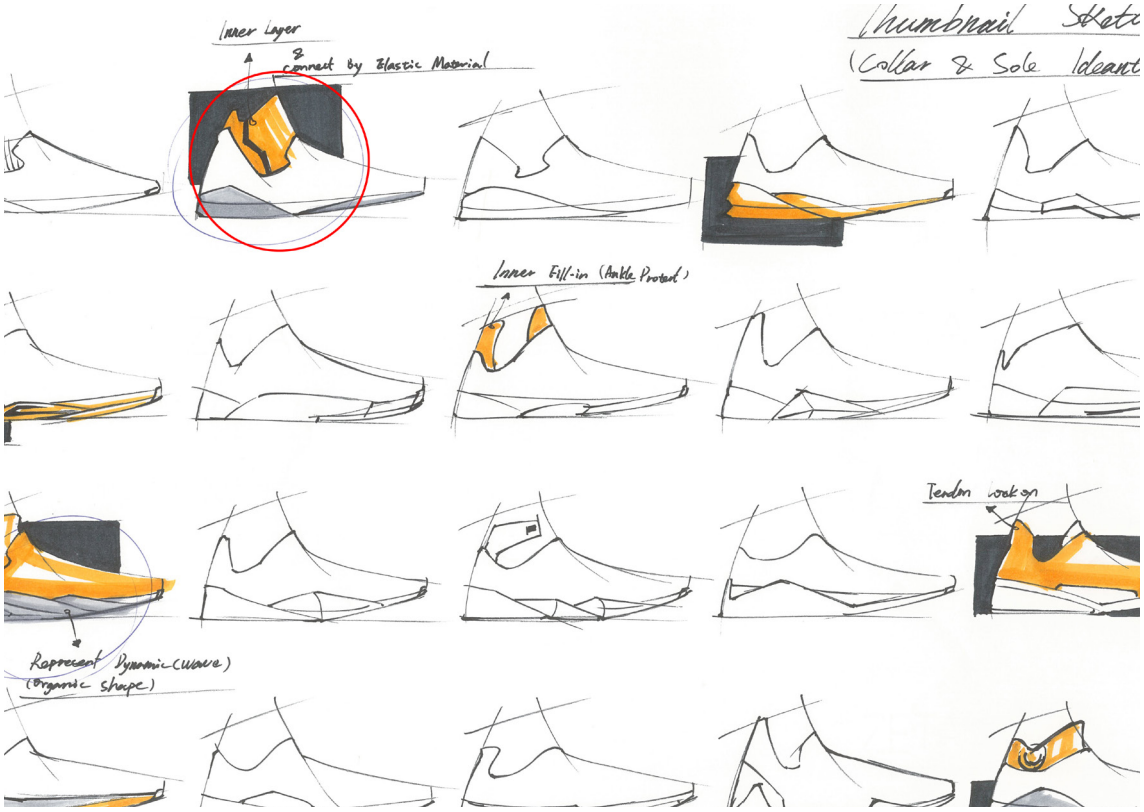

Figure 58. Concept generation- thumbnail sketches 1

From my research and observation, the midsole is a key component to communicate aesthetics in modern basketball footwear design. In the circled drawing in Figure 59, the shape of the midsole is my focal point and uses design references to communicate an athletic design language. Speed, motion and agility is communicated through directional elements in the sole. As discussed in Chapter 3, agility and speed are required for players in the guard position, streamlined shapes represent flow and motion whereas the sharp curve provided a representation of speed.

Figure 59. Concept generation- thumbnail sketches 2

Minimizing manufacturing processes and reducing material waste, a complete upper, as circled in figure 60 is one of the trends in current basketball footwear design. If constructed of an appropriate material, moreover, an adaptive and flexible upper provides better moving ability.

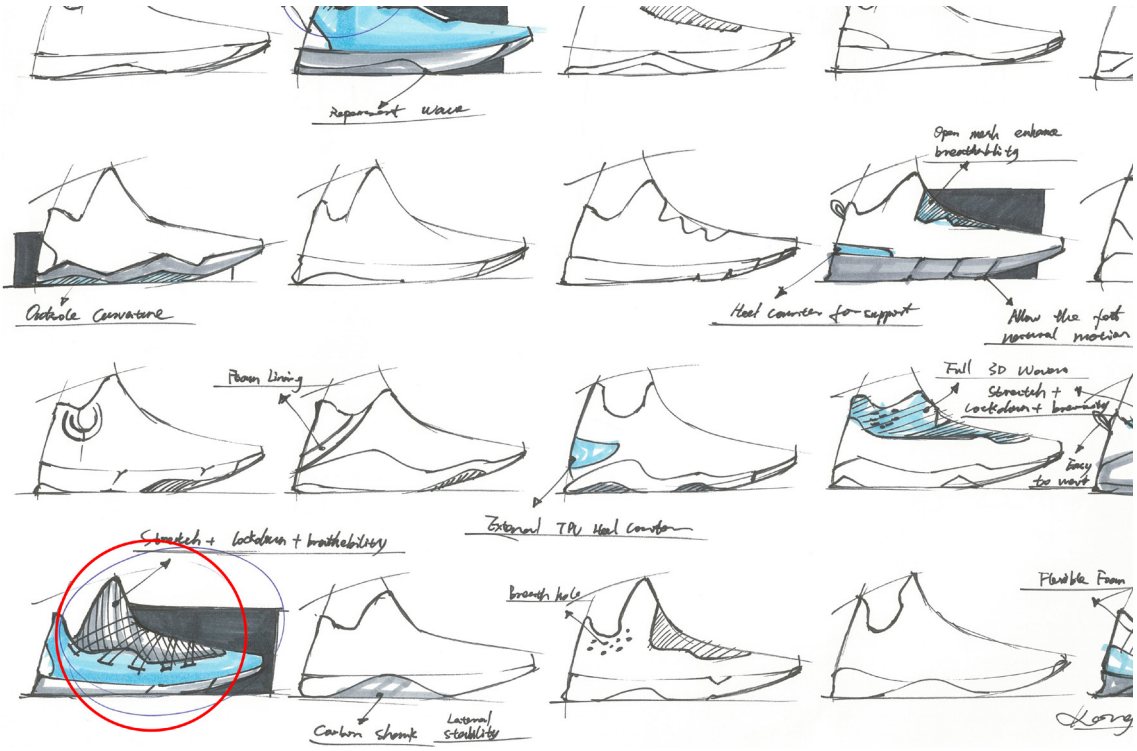

Figure 60. Concept generation- thumbnail sketches 3

6.1.1. Detail Drawing

After thumbnail sketches, I select some aspects of design, from those I highlighted to develop further. In this development stage, I was looking for more specific visual references and inspiration to advance my design intentions. My drawings, focused on the flexible upper, midsole cushioning, ankle support, innovative closure system, outsole pattern, and maximising the bare foot function. More drawing can be viewed in Appendix 4. I further explored several solutions from different elements to achieve an innovate basketball footwear both in performance and fashion aspects. At this stage, colour is used only to differentiate visual references or highlight design features.

The comfort and structural functionality, this design concept (Figure 61) centres on the midsole cushioning and a flexible upper. Combining structure and material cushioning together in this concept, appropriate density EVA foam is integrated with a shock absorption structure to provide extra cushioning especially on heel regions. The upper texture is inspired by "Adaptive Folding Structure" that designed by Thomas Diewald (pinterest.nz), combined with engineered knit technology. This combination has the potential to deliver better stretchiness, breathability, and adaption to foot surface for comfort and free motion. The aesthetic in this concept is influenced by Mercedes design sculpture called "Mercedes Benz Aesthetic 125" (mercedes-benz.com), organic forms and the flowing forms of nature to communicate an agile, adaptive design.

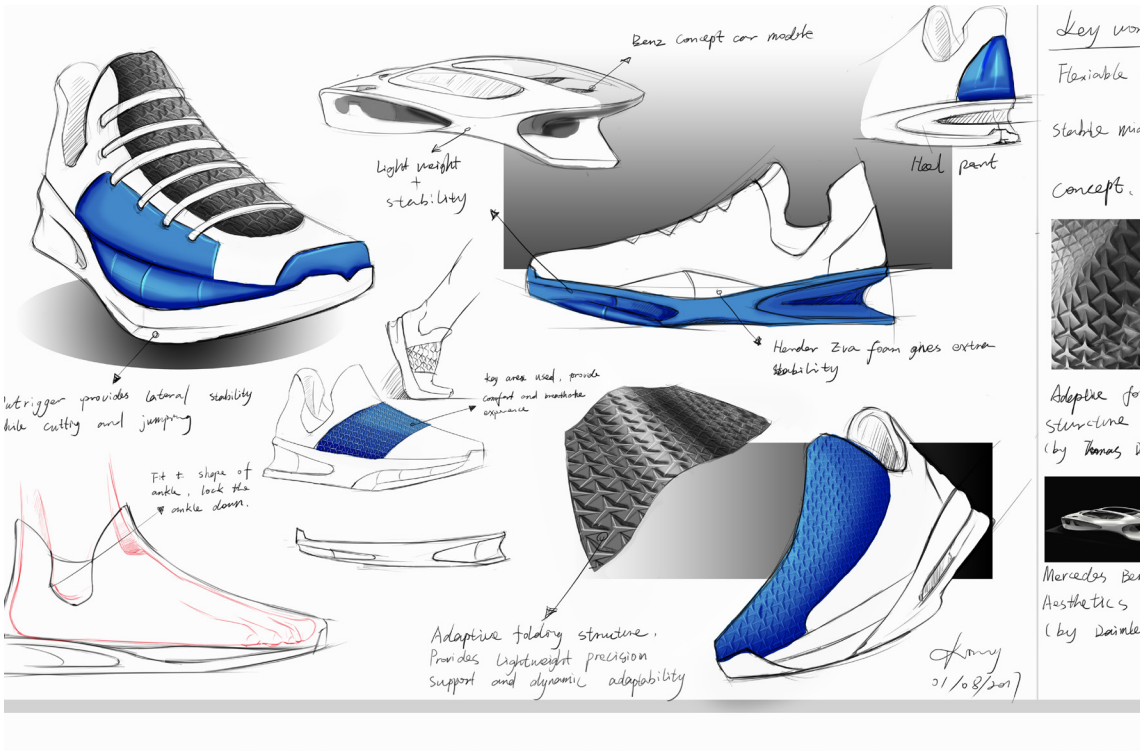

Figure 61. Concept generation - detail drawing 1

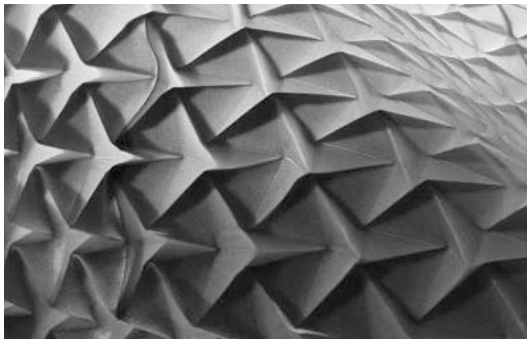

Figure 62. Adaptive Folding Structure

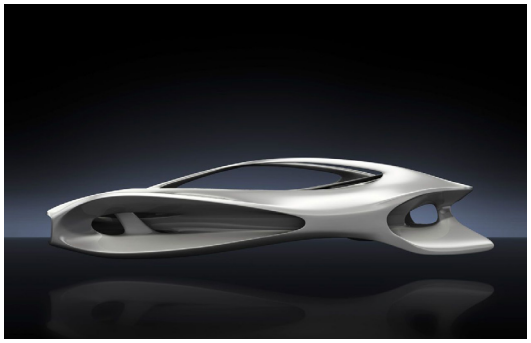

Figure 63. Mercedes Benz Aesthetic 125

In figure 64, this concept I emphasised the outsole and collar part. Referring to the guard player athletic profiles, traction and lateral stability are the main features in this concept. An Outrigger on the outer side of the sole gives lateral support to reduce the risk of foot eversion. The extended outsole on the inner side provides an extra friction area during cutting movements.For the collar concept, softer fabric on the collar gives the ankle more moving space, stitched to the upper to keep enough reinforcement. The aesthetic was inspired by the assertive flow line of a shark with streamlining to express motion.

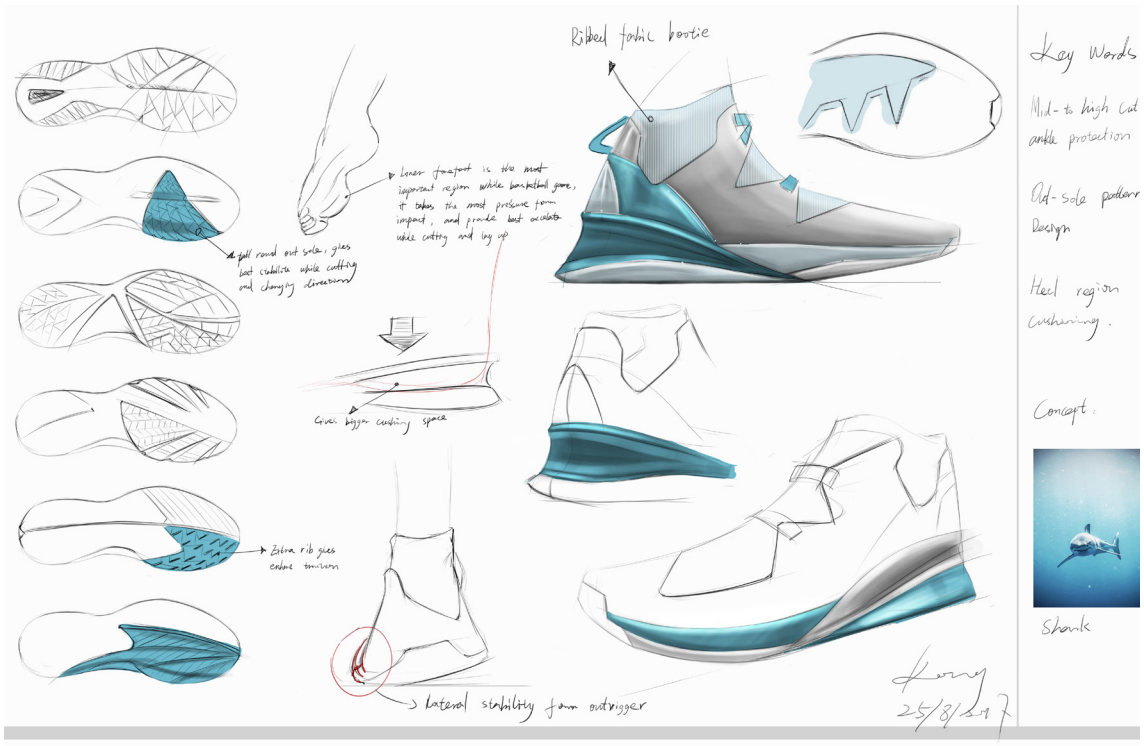

Figure 64. Concept generation - detail drawing 2

6.2. Design Development

Design development narrowed down and recombined key features of previous concepts together in one design proposal. Adaptive upper, structure cushioning, adjustable collar and new closure system are the most critical concepts features pulled through for development. Colour palettes are established in this stage.

6.2.1. Colour Palettes

From the fashion trends review and forecast journal "View 2" (View 2, 2017), two colour palette concepts were selected and adapted for this research project. Forecast for Autumn/Winter of 2018, they relate to performance and active wear corresponding to my design criteria and aesthetic ambition.

Professional basketball players have higher athletic ability than most people, and they are like warriors on the court, they always pursue challenges. These two concept colour pallets “Winter Warriors” and “Hyper Human” align with basketball players dramatic active sports profile.

Figure 65. AW 18 Active concept: Hyper Human

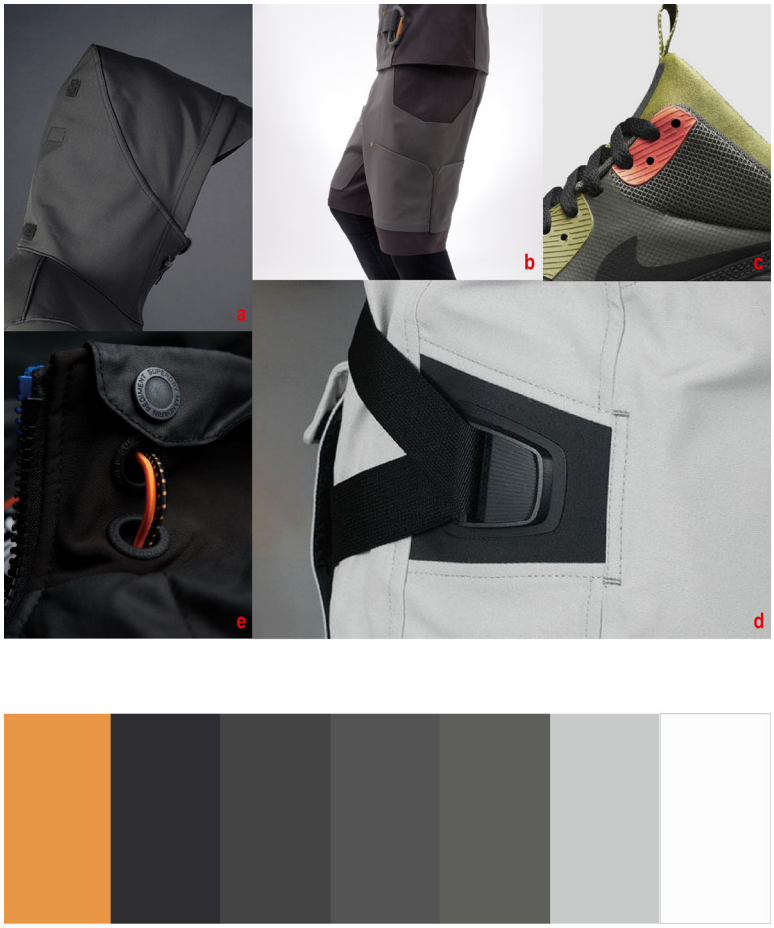

Figure 66. AW 18 Performance concept: Winter Warriors

6.2.2. Concept Development

Concept development included possible materials, working principles and structural explanation for each design selected for expansion.

The design in figure 67 integrates an adjustable collar, lightweight and stable outsole, regional cushioning and adaptive upper, to produce a complete product. The adjustable collar resolves a problem identified in interviews with players, as an adjustable collar allows players to set up either higher or lower ankle support according to individual requirement and situation, providing a customisation feature for the end user. The lightweight and stable outsole provides material savings and creates gaps between midsole and outsole to further reduce materials but provide enough stiffness to maintain foot stability. Different density and resilience cushioning material addresses specific regional cushioning requirements of forefoot and heel. The "adaptive folding structure" and "Mercedes Benz Aesthetic 125" are the upper and aesthetic concepts. The AW18 colour palette - Hyper Human is used.

More concept development drawing is attached in Appendix 5

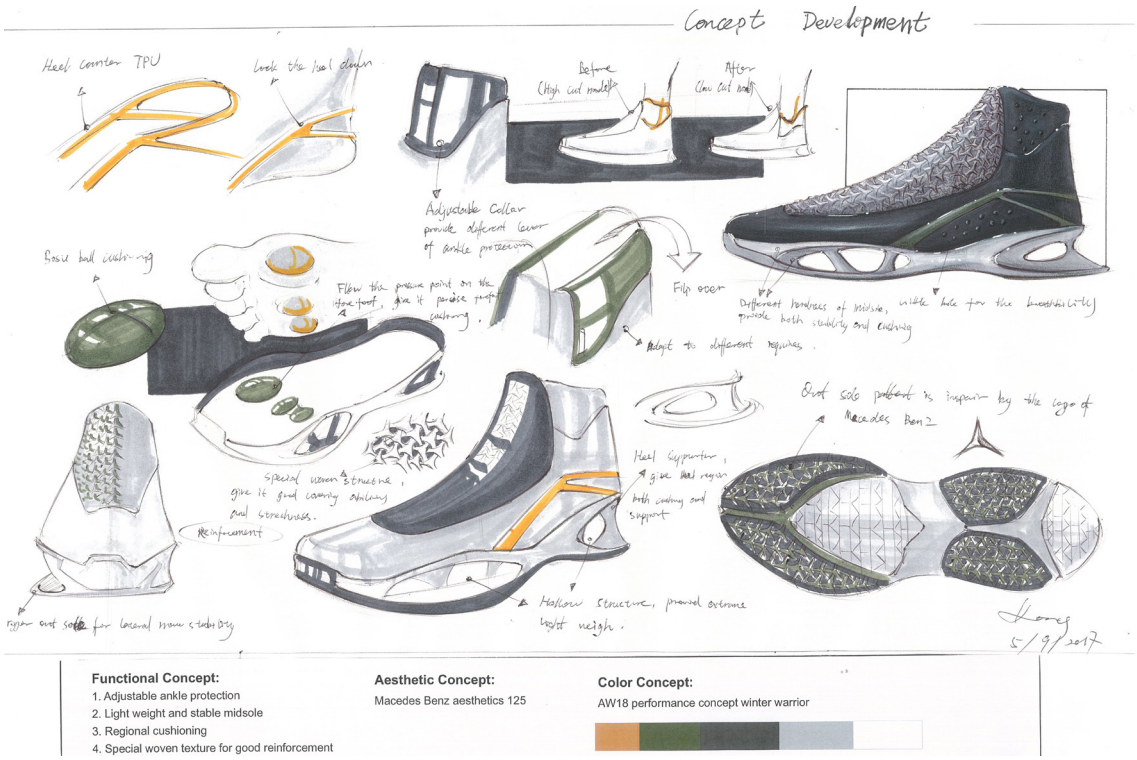

Figure 67. Concept development drawing 1

Figure 68. Concept development drawing 2

The integrated strap closure and extend outsole concept are brought together in this design (Figure 68). The modified line and shapes of midsole provides a smoother aesthetically. AW18 active appeal colour palette concepts 'Hyper Human' is presented in this developed concept.

6.3. Refined Design

The refined design resolves aesthetic details, consolidates functional features of midsole, outsole, adaptive upper, innovative closure (Drawing69, 70 and 71). The adjustable collar concept is resolved through an origami-like structure, a foldable ankle support that gives players a chance to modify and adjust the collar height while they play on court. And the aesthetic of midsole are consitent with the concept of "Mercedes Benz Aesthetic 125", it also combined both structure and material method of cushioning to provided better performance. For convenience a new closure system without laces makes it easier to take on and off. Drawing 69 and 70 are base one the reinforce strap which is quite common in basketball shoe design which are not innovate enough for me. But in the drawing 71, I used the mechanism principle of an auto lock paper box (Figure 72) that holds while under pressure.

Figure 69. Refined design drawing 1

Figure 70. Refined design drawing 2

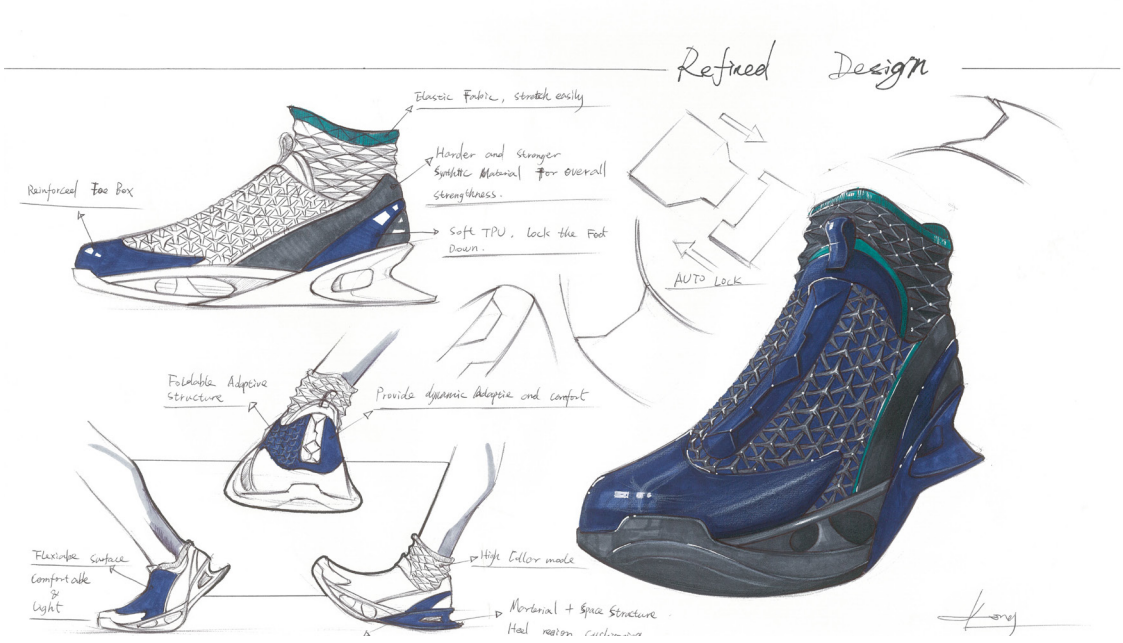

Figure 71. Refined design drawing 3

The final refined design addresses issues and concerns identified through research and responds to identified design considerations, criteria and objectives. The following prototyping process are all base on these and it will effectively related to my final design, and the detail of prototype investigation and techniques are documented in appdix 6.

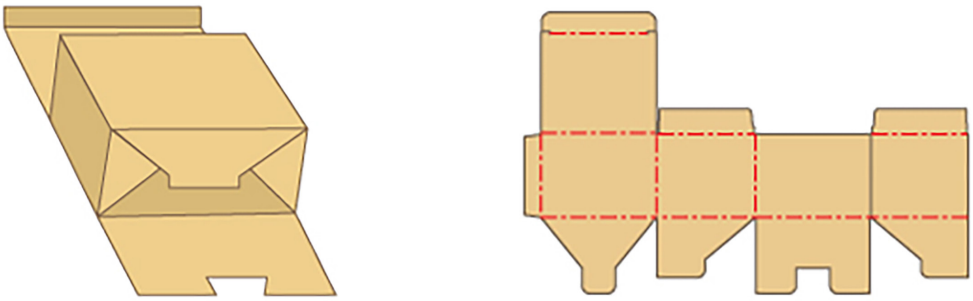

Figure 72. Auto locked paper box

7.0. Final design

Branding

“The nature of smooth”

If this shoe is developed and manufactured as I have designed, “The Nature of Smooth” is the next step in the evolution of the basketball shoe.

The smooth one piece upper is breathable, flexible, engineered knitted fabric. Cushioning throughout the shoe is customised to the needs of a Guard, and the specially shaped outrigging , smooth lines, and a carbon fibre sole provides stability and the ultimate in traction combined with flexibility. The unique collar, of the same material as the upper, can be folded up or down to alter the balance between support and restriction to the player’s natural gait. To round off the design, the specially designed closure adds to the smooth look. This shoe makes an important contribution to a player’s smooth image.

Figure 73. Logo development

Figure 74. Brand Logo

Digital Rendering

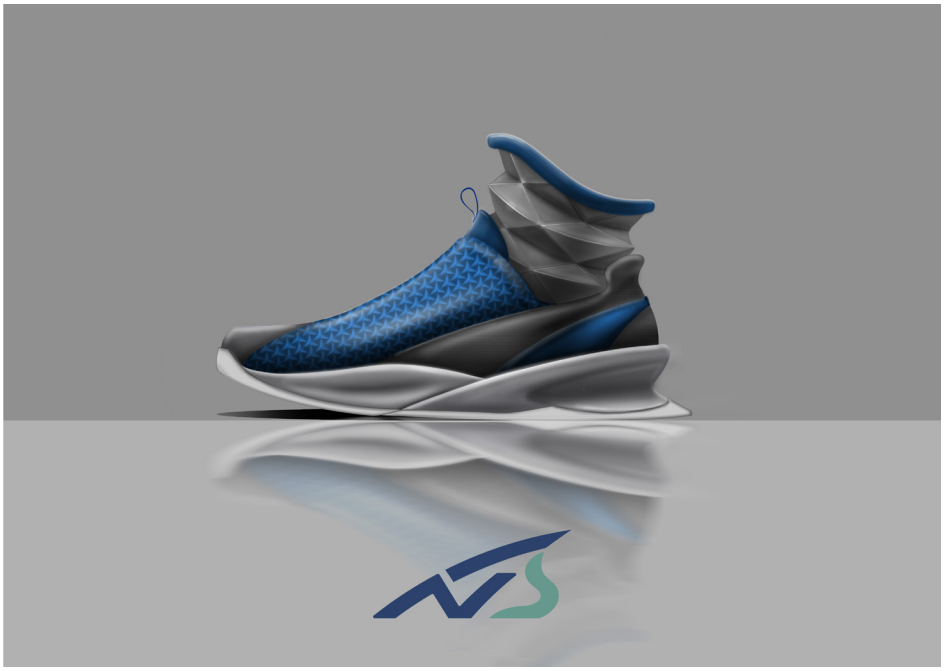

Figure 75. Outer side lateral view

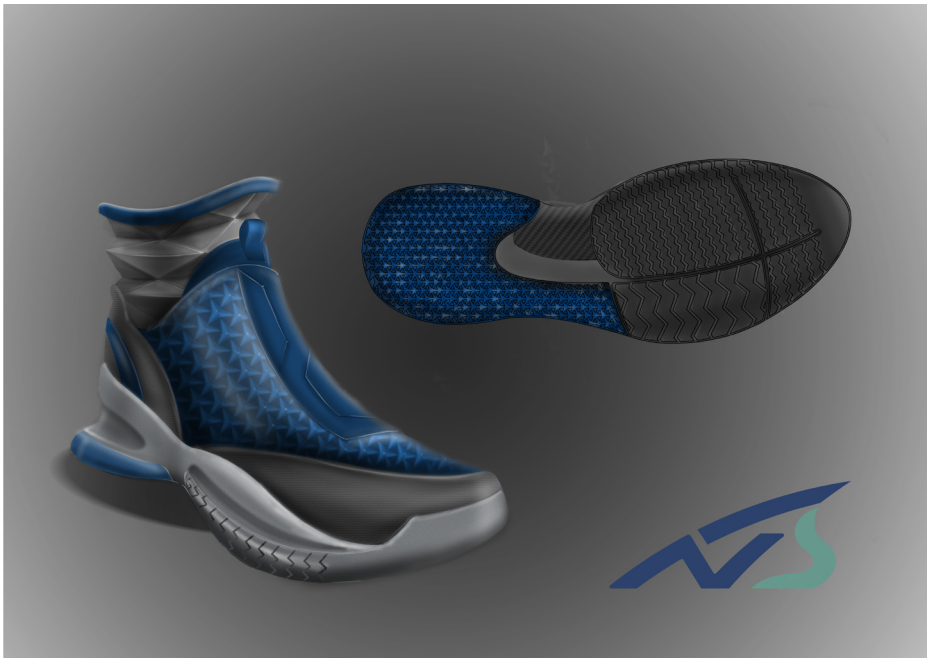

Figure 76. Inner side lateral view and sole pattern

Figure 77. Usability of collar

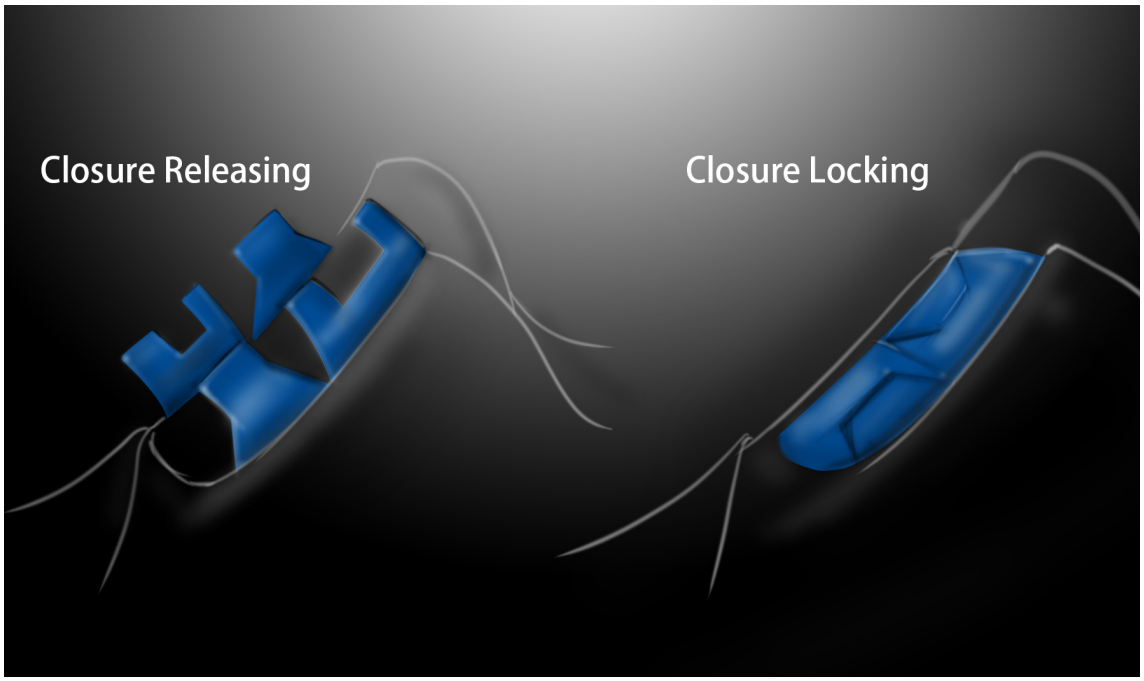

Figure 78. Usability of closure

Figure 79. Colour proposal - AW18 Performance Concept: Winter Warrior

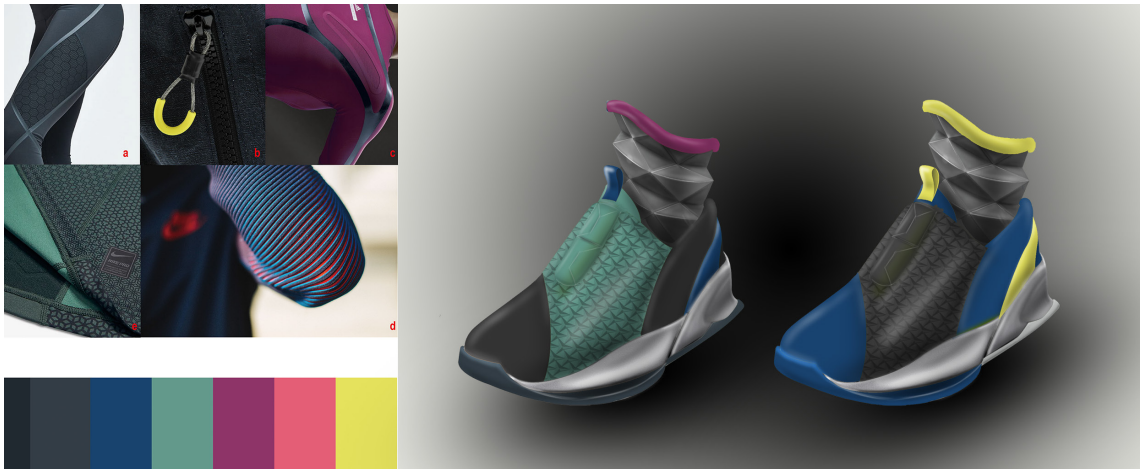

Figure 80. Colour proposal - AW18 Active Concept: Hyper Human

Final Prototype:

Figure 81. Outer side lateral view

Figure 82. Inner side lateral view

Figure 83. Front view

Figure 84. Back view

Figure 85. Top view

Figure 86. Bottom view

Figure 87. Knitted fabric with foldable dynamic structure.

Figure 88. Origami inspired adjustable collar structure.

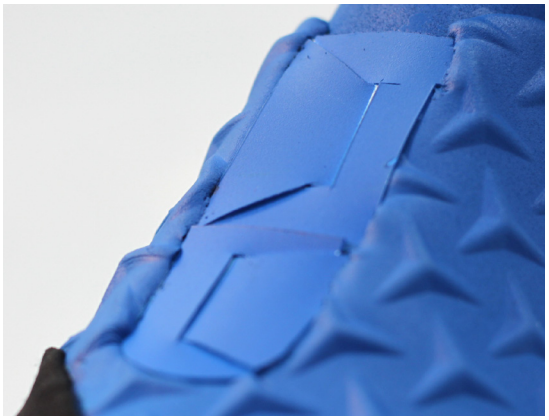

Figure 89. Auto-lock closure system

Figure 90. Heel counter TPU reinforcement.

Figure 91. Lateral outrigger

Figure 92. Redesigned herringbone outsole pattern

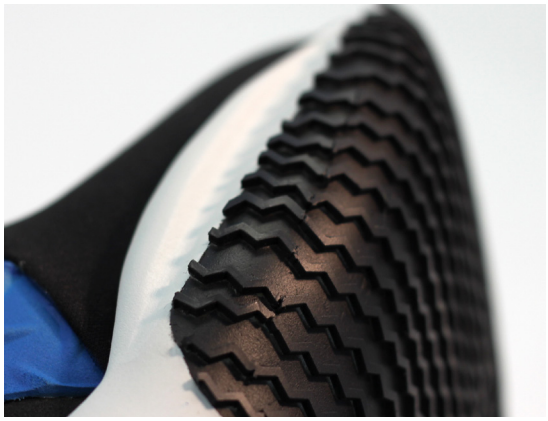

Figure 93. Inner side extend outsole

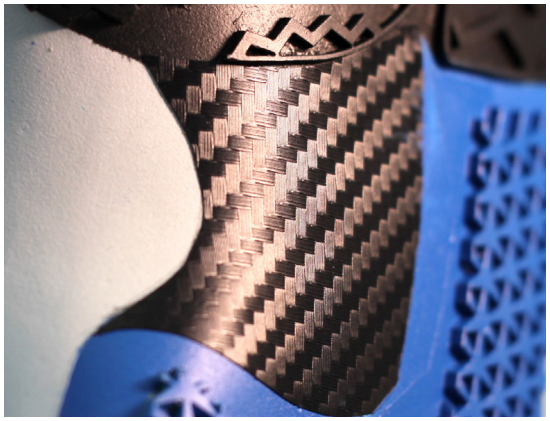

Figure 94. Carbon fibre made midsole stiff shank

8.0. Conclusion

The aim of this design research project was to design basketball footwear that integrates performance, injury preventing and aesthetic style for the professional guard position player.

The broad context review revealed basketball shoe design have been in development for over a hundred years. Case studies showcased performance and aesthetic features of each period. After the 1960s, significant changes appeared every twelve to fifteen years, corresponding to materials and technological developments. Basketball shoes have established their own fashion niche with sports fans and the sneakerhead subculture expanding the overall commercial market size. The substantial essence of basketball shoe design has however, continued to focus on preventing injuries and enhancing player performance.

Primary research provided an effective means of immersing the designer (myself) into basketball culture, user experience and shoe design. Interviewing professional players provided some unexpected insights as well as corroborated contextual research sources.Training and self-user trials provided an intimate user experience and insights into design features that would be required for this project. Reverse engineering provided manufacturing insights into components and assembly that informed the understanding of the sequence of events and processes required in a sophisticated basketball construction.

Innovative, new collar structure and closure system, and modified midsole cushioning, along with the overall aesthetic design are the major elements that were developed in this design, in response to the issues identified in contextual and primary research. To deliver the potential that the collar concept design leverages, the collar design will require further functional prototyping to develop the material characteristics able to deliver the designed collar structure. Without access to the advanced manufacturing facilities required to manufacture the customised mesh, foams and other materials used by basketball shoe manufacturers, the unique collar design could only be simulated, using materials comparable in part to the planned material. The performance, adjustability and level of support for the ankle in either high or low collar mode can only truly be evaluated when the designed materials are used.

The midsole physical design, cushioning, materials selection and manufacture technique are also critical aspects needed to deliver designed benefit and performance. Further experimentation developing functional prototypes would be required to completely resolve these mechanical aspects of the design.

The final design presents a fresh and innovative aesthetic integrated with specific performance features linked to product benefit and elevated user experience. The design attends to injury prevention through the physical design of the shoe and specification of materials. Basketball shoes are a sophisticated high technology product that draws on the designer’s ability to compromise, innovate and always be attentive to new technologies along with fashion trends. This concept design uses the manufacturer’s claims for products and used in similar ways in other designs to forecast a shoe that accomplishes more that other shoes in the market.

The “Natyre if smooth” cincept basketball shoe delivers a product focused on the performance requirements of the guard position integrated with materials innovation, injury prevention and with a fresh aesthetic style.

9.0. References

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Figure List

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Figure 58. *Concept generation- thumbnail sketches 1*. Author (2017)

Figure 59. *Concept generation- thumbnail sketches 2*. Author (2017)

Figure 60. *Concept generation- thumbnail sketches 3*. Author (2017)

Figure 61. *Concept generation - detail drawing 1*. Author (2017)

Figure 62. *Adaptive Folding Structure.* Retrieved 09 Jul, 2017 from https://www.pinterest.nz/pin/480055641504019730/

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Figure 64. *Concept generation - detail drawing 2.* Author (2017)

Figure 65. *AW 18 Active concept: Hyper Human*

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Figure 65b. *Zipper*. Retrieved 13 Aug, 2017 from http://thewellcollective.tumblr.com/post/114848757995

Figure 65c. *Adidas by Stella McCartney in 2007.* Retrieved 13 Aug, 2017 fromhttp://www.coroflot.com/Susi_Auzinger/Adidas-by-Stella-McCartney-2007

Figure 65d. *Nike Pro HyperWarm Men's Long Sleeve Training Top*. Retrieved 13 Aug, 2017 from https://store.nike.com/us/en_us/pd/pro-hyperwarm-mens-long-sleeve-training-top/pid-11106624/pgid-11625174

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Figure 66. *AW 18 Performance concept: Winter Warriors*

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Figure 66b. *TAD gear | Stealth Aero Hood*. Retrieved 13 Aug, 2017 from https://tripleaughtdesign.com/shop/apparel/

Figure 67c. *Nike air max.* Retrieved 13 Aug, 2017 from https://lemanoosh.tumblr.com/post/72002413957

Table List

10.0. Appendix

Appendix 1 Foot Sculpture and Casting Process

Figure 95. PU foam foot sculpture

Figure 96. Foot modle casting

Appendix 2. Interview Question.

1. What do you think is the most important characteristic in a pair of basketball shoes?

2. What is your favorite basketball shoes technology (e.g. Nike air max or Adidas boost etc.)?

3. Which is the most comfortable basketball shoe you have worn?

4. How do basketball shoes affect your performance? And how does it work?

5. Which parts of your feet gets the most pressure while playing a game?

6. What is the biggest issue for you regarding basketball shoes for you & what features of basketball shoes bother you the most?

7. If you were to design a pair of basketball shoes, how would you improve what is available?

8. Do you prefer
- active performance or high ankle support?
- shoes with no laces?
- softer or harder insole and midsole?
- Is colour an important consideration for you when selecting basketball shoes

Appendix 3. Selection of Thumbnail Sketches

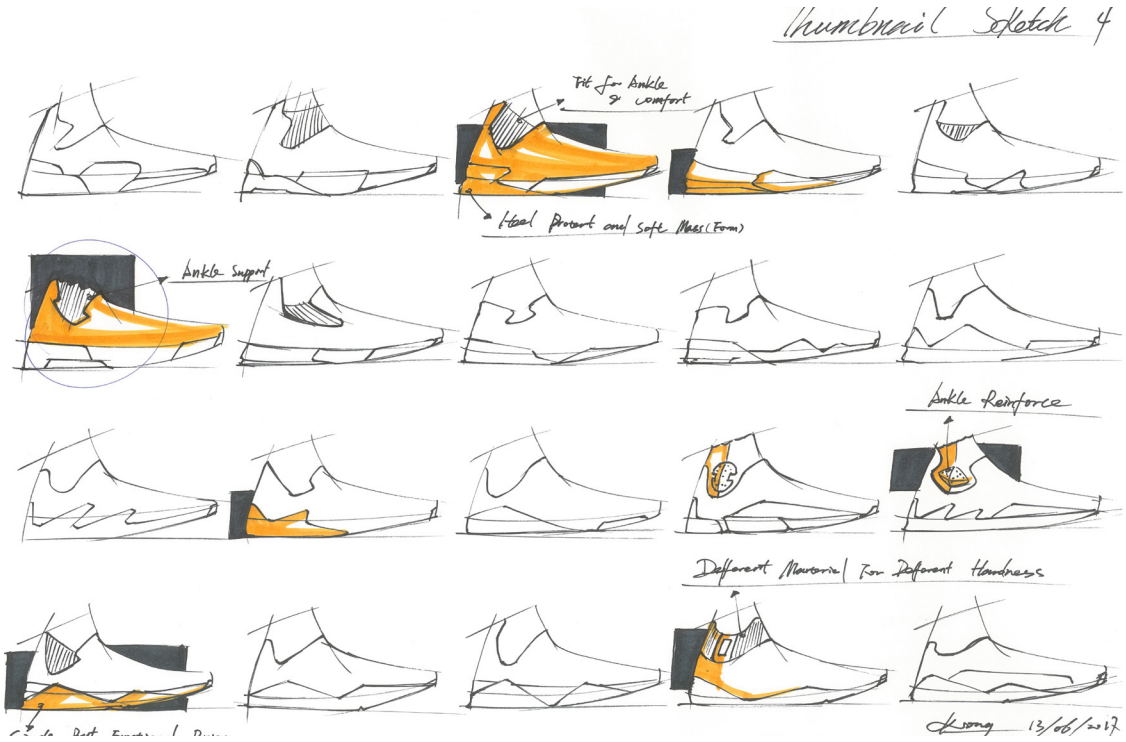

Figure 97. Thumbnail sketch 1

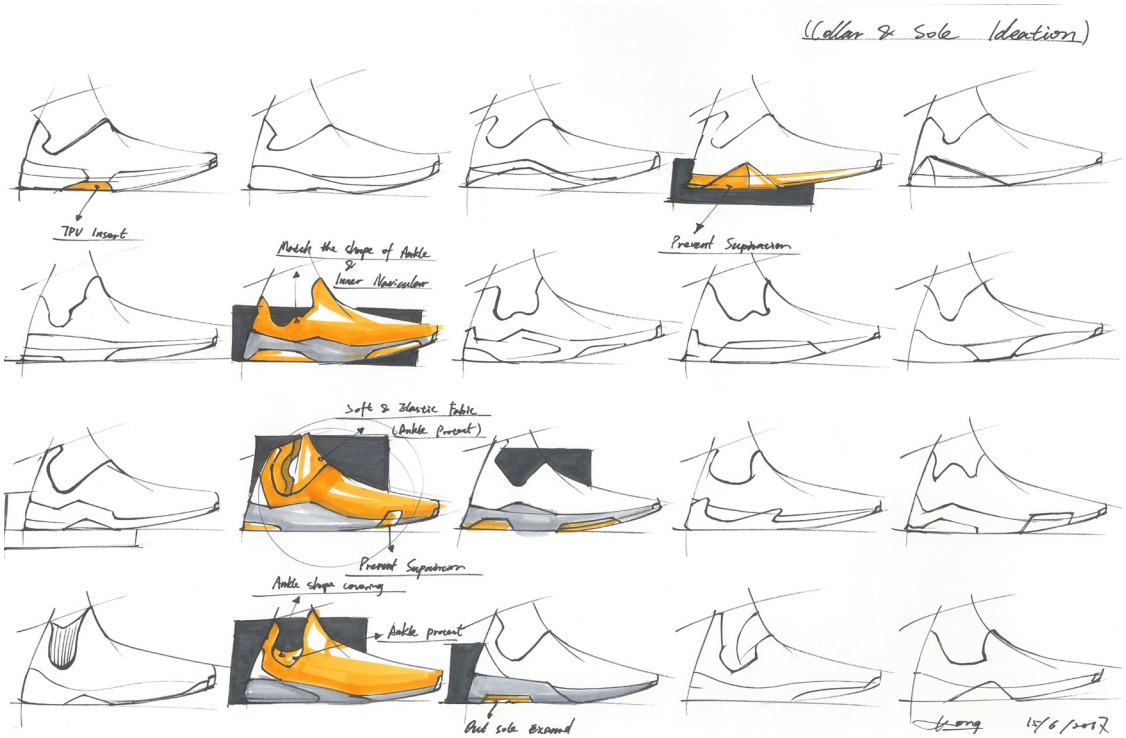

Figure 98. Thumbnail sketch 2

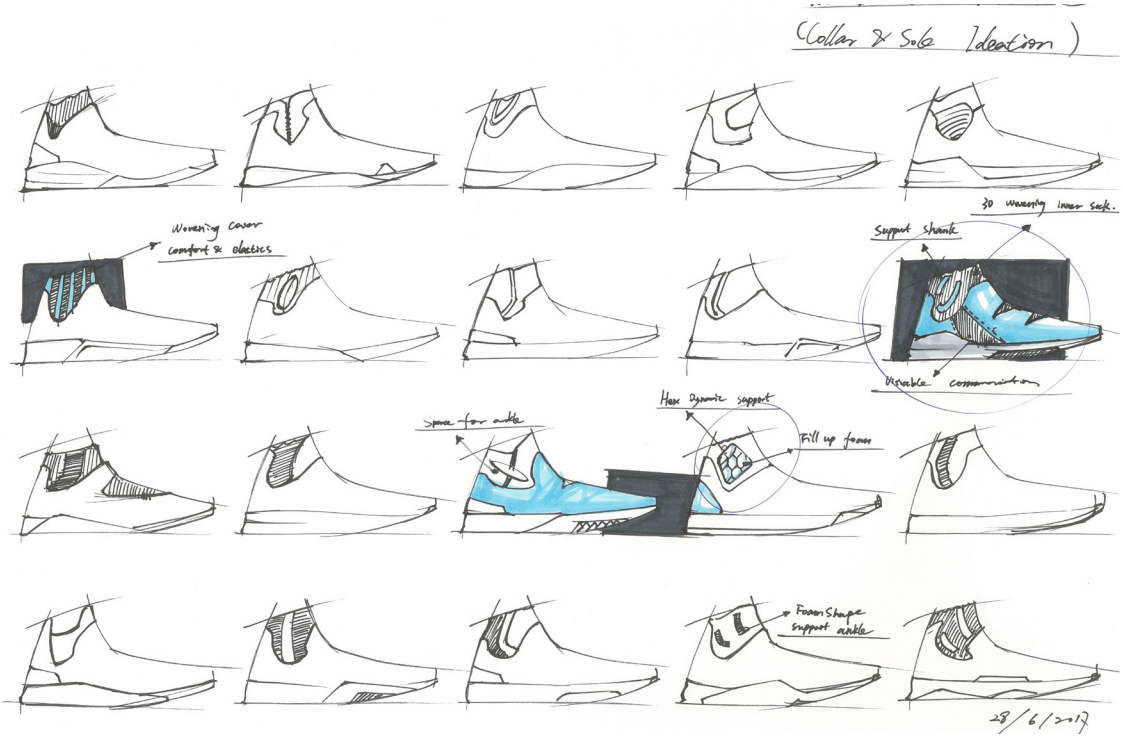

Figure 99. Thumbnail sketch 3

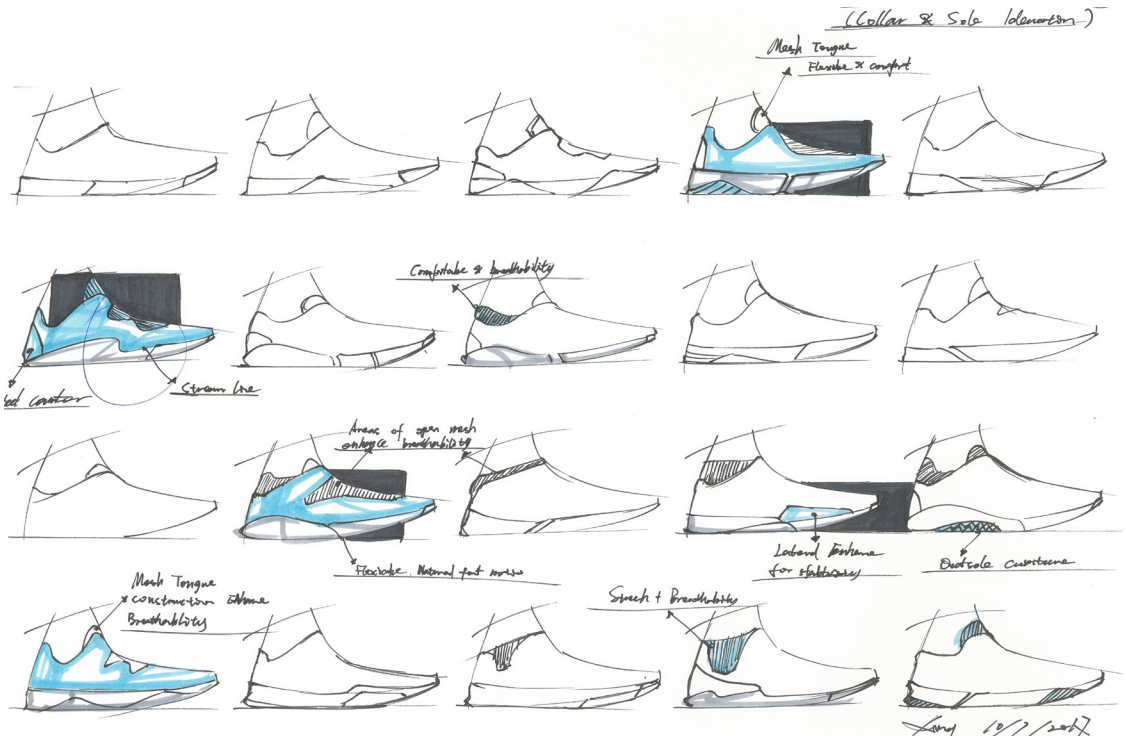

Figure 100. Thumbnail sketch 4

Appendix 4. Selection of Detail drawing

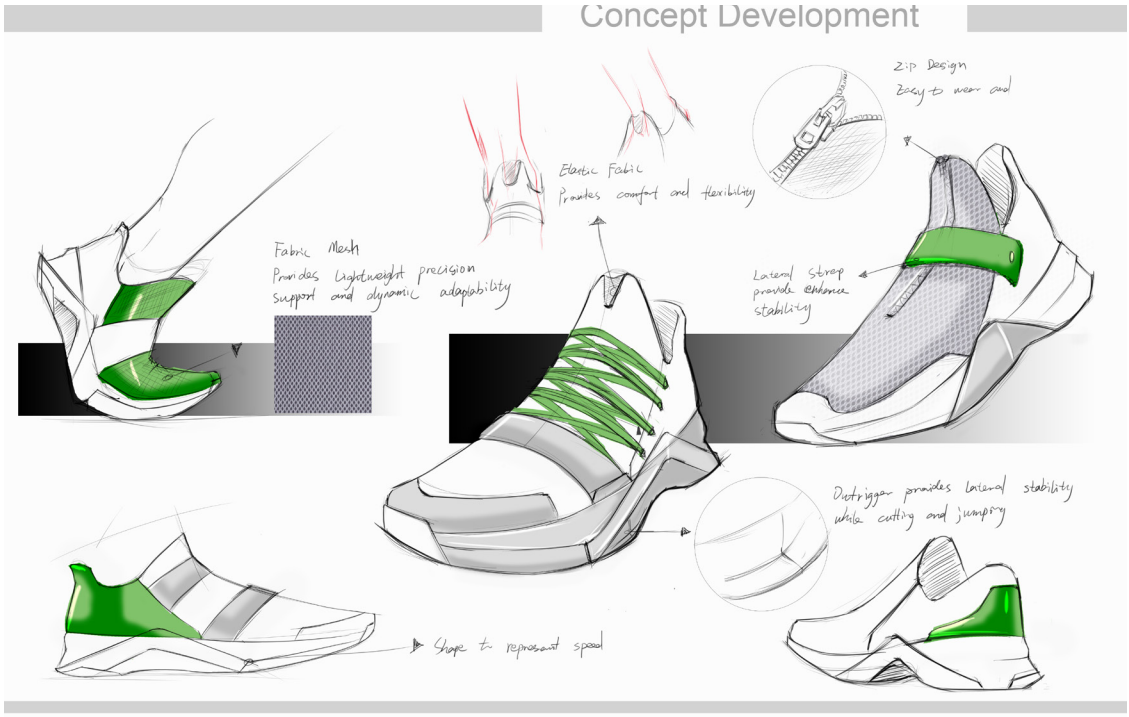

Figure 101. Detail Drawing 1

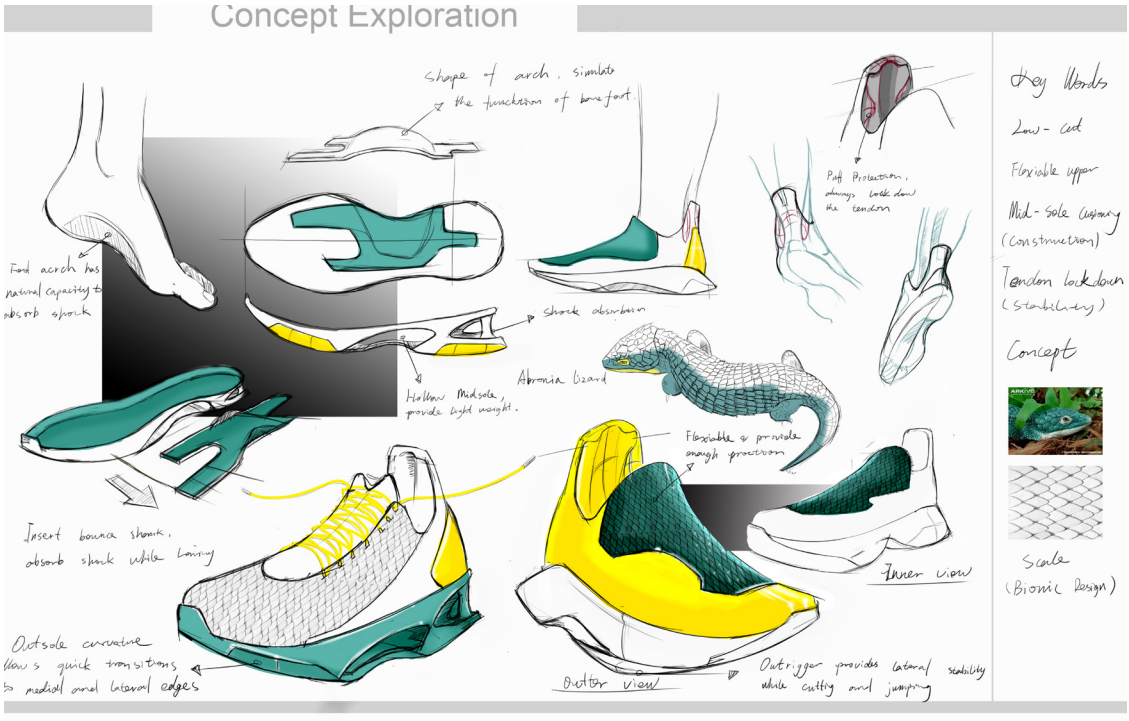

Figure 102. Detail Drawing 2

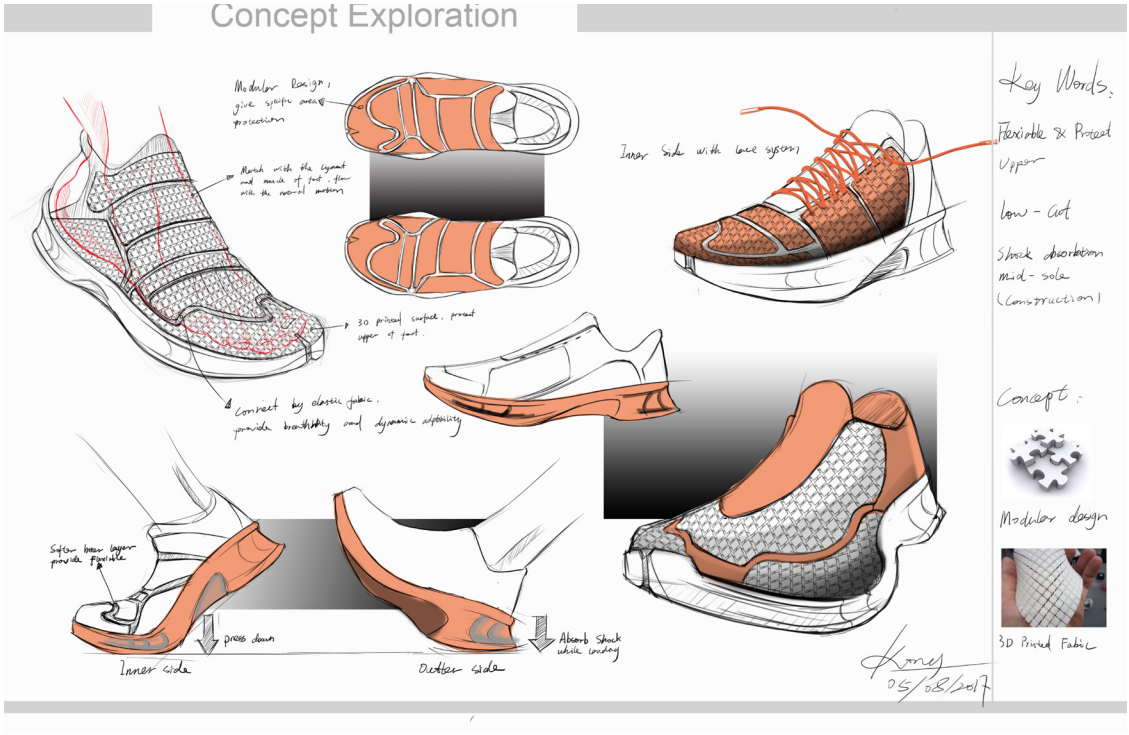

Figure 103. Detail Drawing 3

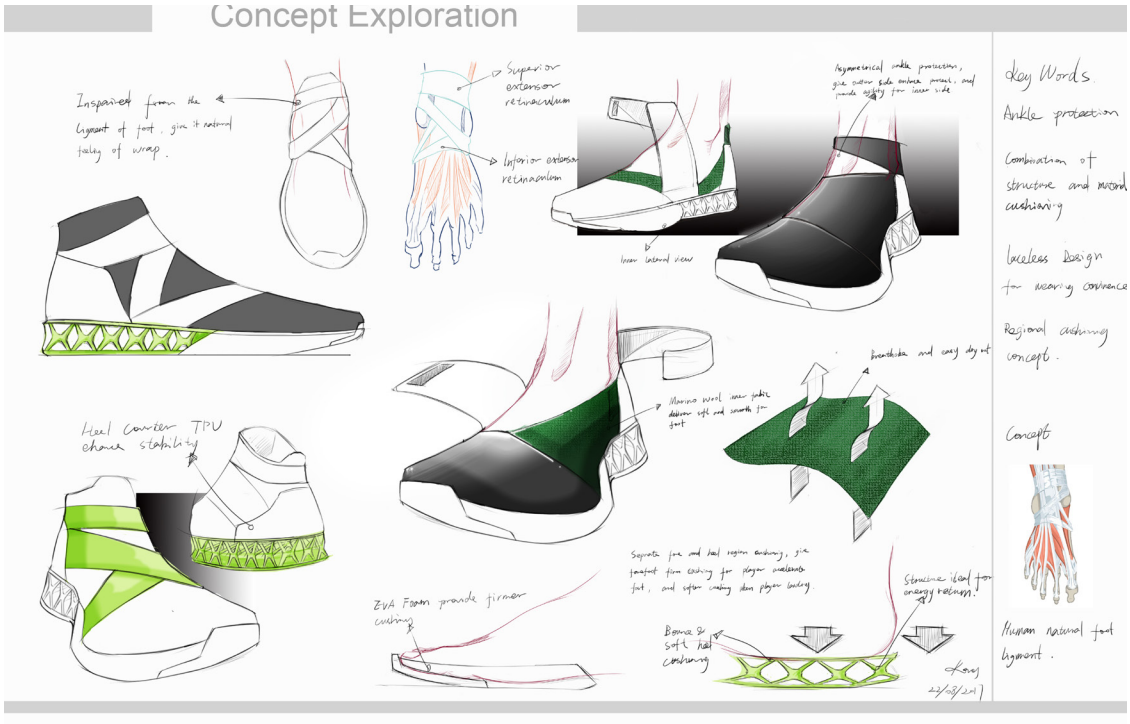

Figure 104. Detail Drawing 4

Appendix 5. Aspects of Design Development

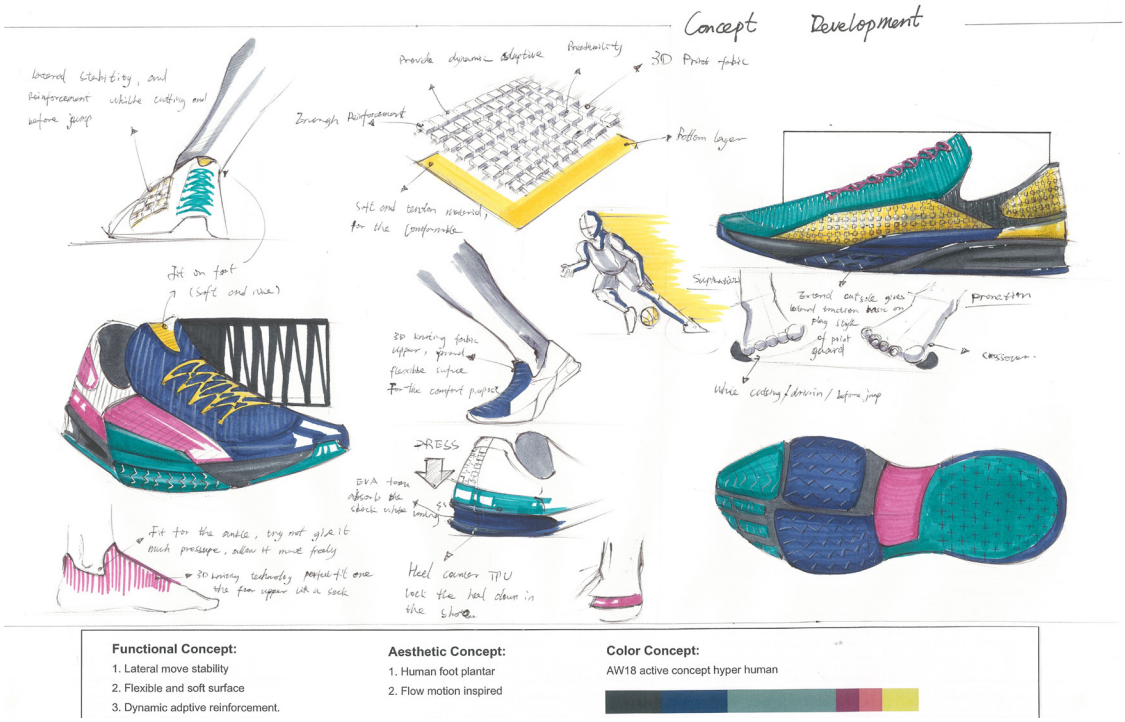

Figure 105. Design Development 1

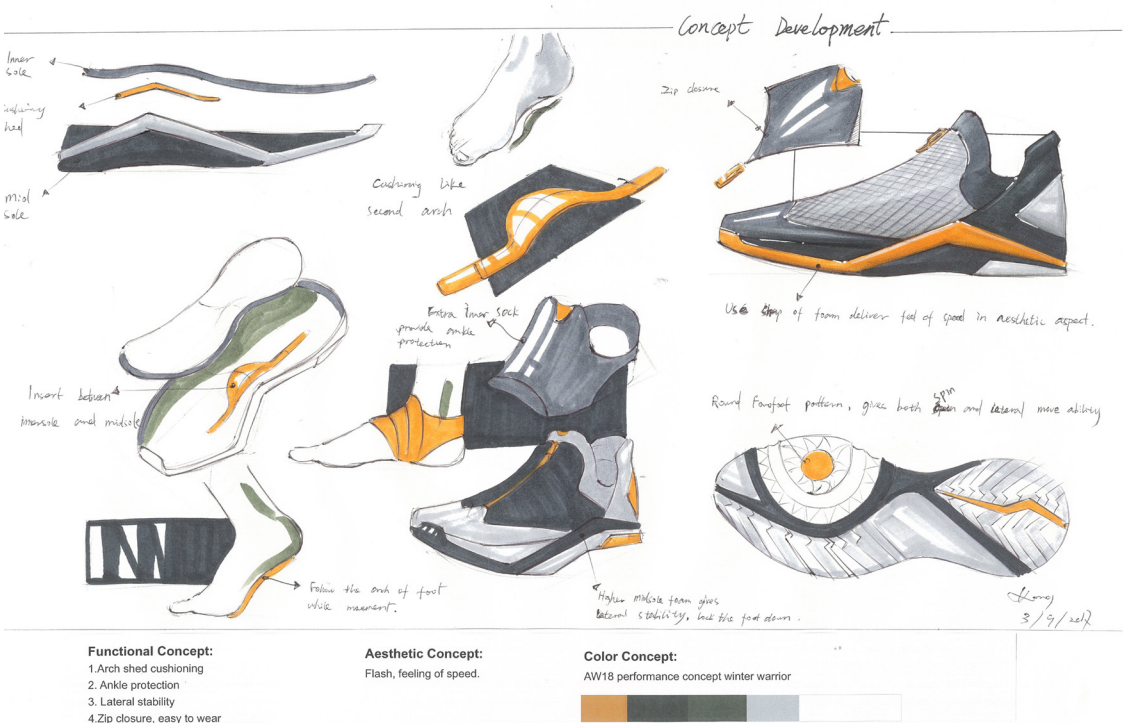

Figure 106. Design Development 2

Appendix 6. Examples of Prototyping

Polystyrene foam modelling process

Figures 107 to 112 show the initial modelling of the foam for the midsole. No attempt was made to include the different hardness and densities of foam that would be used in the manufactured shoe. My reveres engineering indicated that this was engineered in the manufacturing process and could not be shown in the prototype.

Figure 107. Initial shape of miosole

Figure 108. Midsole shape development

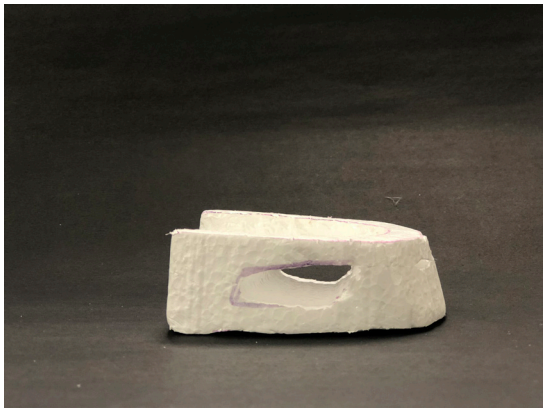

Figure 109. Heel region shape testing 1

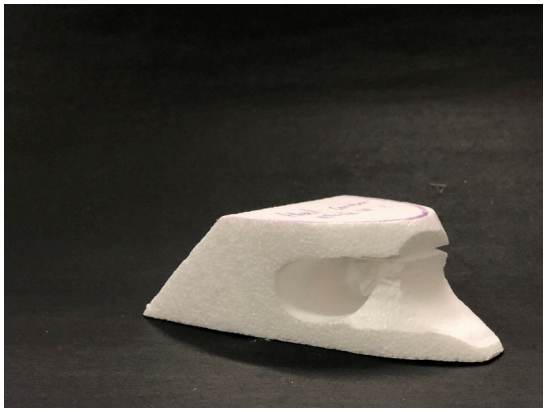

Figure 110. Heel region shape testing 2

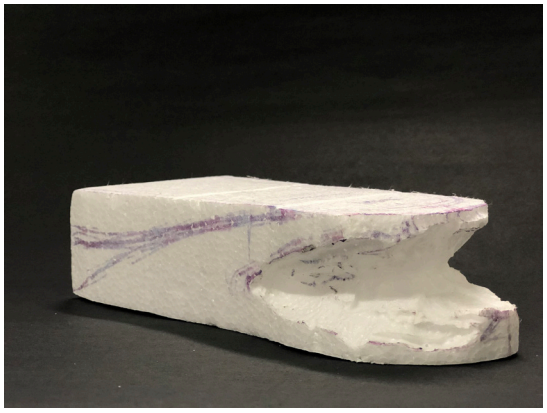

Figure 111. Heel region shape testing 3

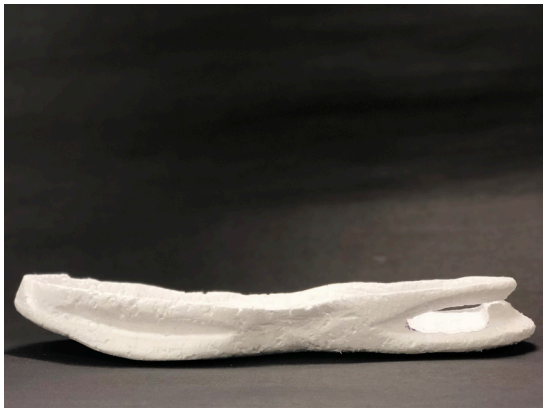

Figure 112. Refined mid sole shape

High resolution foam prototype

At this stage, I used high resolution foam to model my design of the midsole, as showing in figures 113 and 114.

Figure 113. High resolution foam prototype 1

Figure 114. High resolution foam prototype 2

Development of the shoe upper- pattern, texture and collar structure.

Figures 115 to 118 begin the development of the shoe upper. My intention was for the upper to be a single piece. When my initial pattern (Figure 115) was constructed (Figure 116), the sewing lines did not gives the smooth effect that was wanted, caused me to modify the pattern accordingly (Figure 117) to give the smooth profile of figure 118.

Figure 115. Initial upper pattern

Figure 116. Initial pattern test

Figure 117. Modified upper pattern

Figure 118. Modified pattern test

My design intent was to use an engineered knit fabric. Figures 116 to 121 show my exploration of the fabric design and texture for the shoe upper. I began with a paper model to test the effect I wanted from the upper material (Figure 119). To simulate the texture of the knitted effect I used CNC machine with the smallest sized drill bit to make a template (Figure 120), then used vacuum forming to make a test sample. The initial sample (Figure 121) did not give the effect I wanted but an inverted template (Figure 122) produced a material that was closer to the effect I wanted on the knitted fabric (Figure 123). Further experimentation, using a V-cut drill bit to make the template (Figure 124), did not produce any better effect (Figure 125).

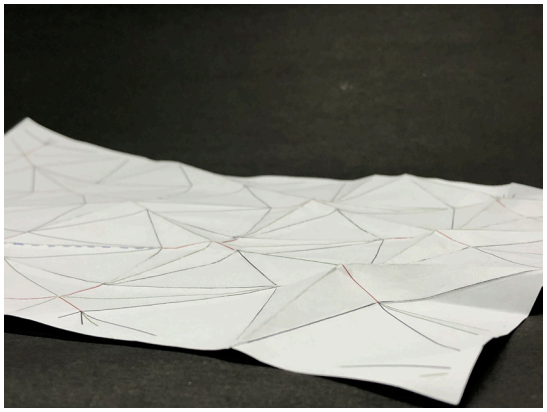

Figure 119. Paper testing

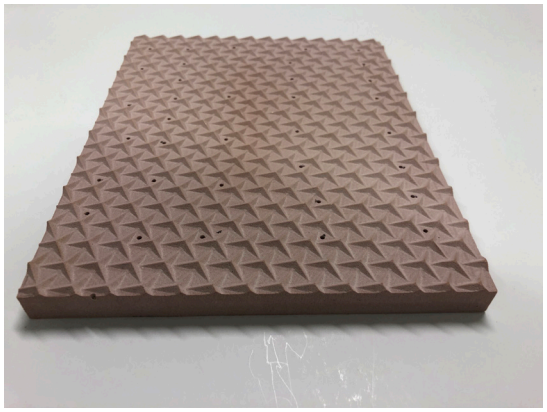

Figure 120. CNC made testing pattern 1

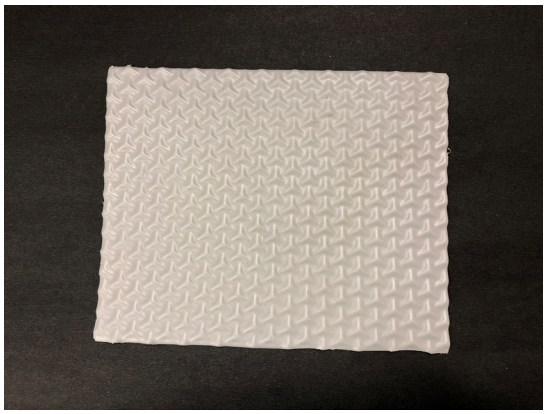

Figure 121. Vacuum forming test sheet 1

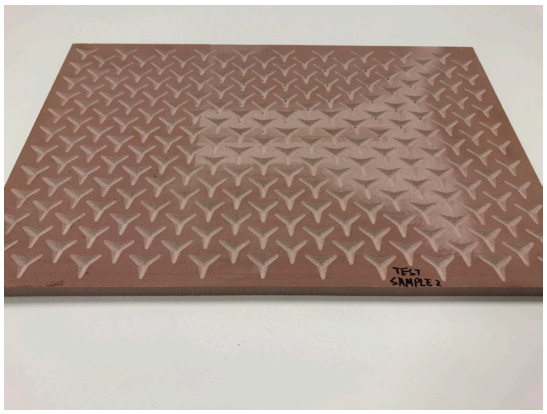

Figure 122. CNC made testing pattern 2

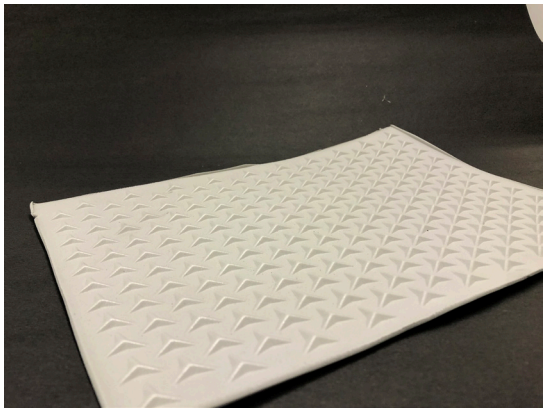

Figure 123. Vacuum forming test sheet 2

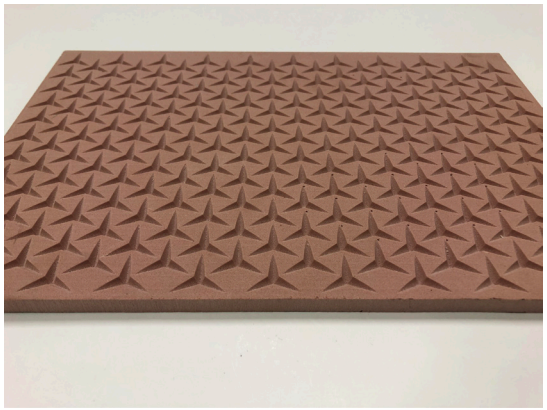

Figure 124. CNC made testing pattern 3

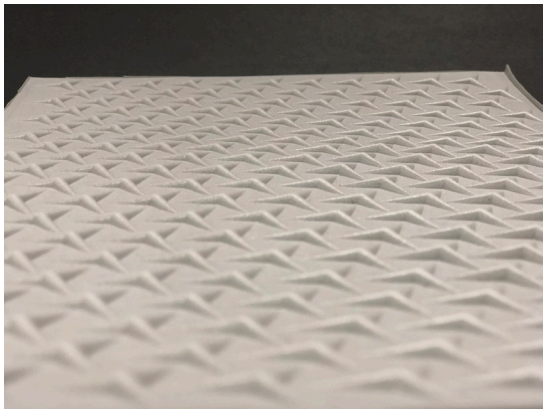

Figure 125. Vacuum forming test sheet 3

In my design concept, the collar of my design will be an engineered knit, attached to the shoe upper. To deliver the potential of the folding collar, the knit would need to be differently engineered. Figures 126 to 129 show the proposed folding, first in polypropylene (Figure 126), then in a firm paper (Figure 127). Figure 128 is the firm paper covered with fabric to simulated the knitted effect, the same size as would be used in the collar, but without the curve needed to mould it to the ankle. Figures 129 show the refined curved structure.

Figure 126. Mock up made by polypropylene

Figure 127. Paper mock up

Figure 128. Combination of paper and fibric

Figure 129. Refined collar structure

Final Prototype Processing

To develop my final prototype I sculpted a clay sole around a shoe last, incorporating all the shaping I earlier developed in foam (Figures 130 and 131). I then cast as a silicon mould (Figure 132) and constructed using a resin formed in the mould (Figures 133). The form was bogged and filled with putty (Figure 134), sanded smooth and then spray putty was applied (Figure 135).

Figure 130. Clay modeling process

Figure 131. Refined Clay model

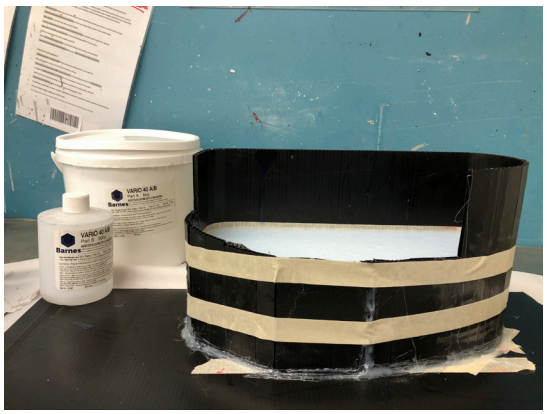

Figure 132. Silicon mould

Figure 133. Resin made midsole

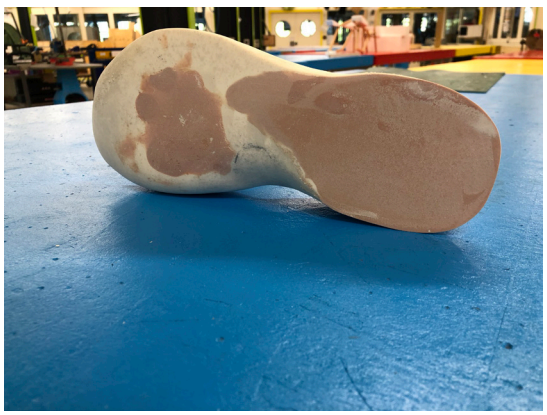

Figure 134. Bogging and sanding process

Figure 135. Spary putty applied midsole

The final prototype shoe was constructed by assemble all different parts, include upper,outsole and collar.Then painted to the desired colour, and process showed following figures.

Figure 136. Assembling test

Figure 137. Out sole making process

Figure 138. Painting process 1

Figure 139. Painting process 2

Figure 140. Final Assembling