Kick Boxing Coaching System

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Kick Boxing Coaching System

by

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Abstract

There are three key considerations when training for kickboxing; correct body position, motivation, and how to achieve different training goals. Training gear available on the market does not provide enough relevant feedback to the user to validate the effectiveness of their training. I will design a coaching system for recreational and avid kick boxers that records user input while also providing an interactive experience that tracks training in a more meaningful way. This is a project focused on user experience and product testing. User Experience requires me to study the response of the human body when it is hit, and the different hardness of materials. Working with my Associate Advisor Lee Davis (boxing coach at Rochester) helps me understand the requirements for boxing training and experience as a professional coach on the use of training equipment in the market, and details for improvement.

Key Words

Kickboxing, Training, Dummy, Mixed Martial Arts, Materials, Sensor, Motion Capture, Modular Design
Introduction

Boxing is a popular competitive sport, a self-defense skill, and a great cardio exercise. People are enjoying the benefits of training for boxing, but this sport is also a highly dangerous sport for beginners because boxing requires a lot of foundational knowledge like foot position and movement, body form and rotation, the angle of your fist, and even how fast and how hard you hit. Without an appropriate training guide, you could acquire bad habits or even get injured. A number of beginners still choose not to learn boxing with a formal trainer for many reasons. First, pragmatic limitations: the user might not have enough money to hire a coach, they may have a difficult time fitting the boxing course into their busy schedule, or maybe the user lives in a location without any boxing gym or coaches. Second, psychological reasons: some people are too shy to exercise in front of others, they could be insecure of their body image, have a lack of confidence in their athletic ability, or even just simply desire personal privacy. Third, they’re too bumptious: some people have a lack of awareness of their own competence, watched too much UFC or learned a few moves from Kung Fu movies and think of themselves as an Ultimate Fighter. As an experienced boxer and wrestler, I want to solve this problem by designing a boxing training system; therefore, I started by doing research of different training equipment on the current market.

There are many types of mixed martial arts training equipment that people use on a daily basis - a dummy, sand bag, speed bag - and they all fit in different price ranges. Take the traditional sand training bag for example. I have replaced many of them during
my years of training. They work especially well when first used, but no matter who manufactures them, the sand will sink to the bottom once the sandbag ages. Therefore, the top part of the bag will be very soft and the bottom will be hard as a rock. Due to the hard bottom of the bag, users will most likely injure themselves because they have the wrong impression of the firmness of the bag. We often see an old sandbag in the gym with tape around it. This is because the cover of the bag breaks first, and the sand starts leaking out. There is really no better way to fix the bag because the entire cover is one piece, and it is almost impossible for the user to repair only the cover.

The high-end training dummy, BOB¹, also has its disadvantages. It is the most popular dummy for multiple styles of martial arts. The original BOB - Body Opponent Bag - is a life-like mannequin with a vinyl "skin" for more realistic self-defense training. BOB features seven height adjustments from 60 inches to 78 inches tall. BOB can be used with or without gloves and is ideal for punching and strikes. BOB only weighs 37 pounds and the user can increase the weight to 270 pounds by filling the base with water or sand. From a personal experience, BOB is not stable. The water in the base always leaks and leaves a ring on the floor and wets the mat. This is a safety hazard, as I once slipped during my training due to the wet floor. Also, BOB is not heavy enough to be stable during training sessions, in other


Figure (1) Image of BOB - Century Martial Arts
words, he likes to bounce around when hit. A study of seven Olympic boxers in weight
classes ranging from flyweight to super heavyweight showed a range of 447 to 1,066
pounds of peak punching force\(^2\). Another study of the force of various punches shows:
peak punch forces are reported to range from 1666 to 6860 N\(^3\) (374 - 1542 pounds).\(^4\)
Energy transferred from punch to target varied widely depending on how heavy the
boxers' hands and gloves were, how fast they punched, and how rigidly they held their
wrists. This shows the need to ensure the quality of training and the stability of the
dummy. A fighter needs a dummy that is equal or greater than their own body weight
because the force exerted from their hardest strike outputs more weight than the
fighters own body weight. Another issue with this bag, is that the screws holding the
rubber to the center plastic post on BOB do not always line up perfectly and have a
tendency to come out from the post. One screw just would not go in as the guide and
threads were too far off; and if you’re missing one screw, the rest will fall out soon. Once
the dummy breaks, there will not be replacement parts to repair it, and the user has no
choice but to buy a new dummy. In the end, BOB is made of one integrated rubber cast
human form. The feeling of hitting him is soft but you can’t distinguish the texture of
each body part.


\(^4\) Walilko TJ, Viano DC, Bir CA Biomechanics of the head for Olympic boxer punches to the face British Journal of
After investigating and comparing different dummies on the current market, the cheaper dummies are poor quality, and the more durable, better quality dummies are overpriced. The current market doesn’t have a boxing dummy that can imitate the feel of human muscle and provide proper physical feedback. Also, only a few dummies allow the consumer to purchase particular body parts in order to lower repair costs. Most importantly, there are no custom designed dummies to fit different types of martial arts training.

**Design Challenges**

To address this gap in the market, I need a dummy that is good for all forms of training (I like to focus on the standing position only). It would be a modular system that allows the user to order their own parts and assemble them to the base. This would be a truly personal training dummy that is designed specifically for one user and their particular training needs. The user could also replace or reorganize the parts to fit into another training style and also save the costs on maintenance.

I also need to build software that can work with the dummy to monitor and coach the user. This training dummy will have a built-in sensor and external coaching system app that is connected to the user’s smart phone. This app can teach users how to box, correct improper posture and technique, give feedback, and motivate the user.
Research & Experiment

I decided to make this dummy a modular design because it allows the dummy to be customized, upgraded, repaired, and for parts to be reused. Module products are meant to support creative processes such as play blocks, and they also depend on standard interfaces between parts, which means each part is designed to fit together.

Figure (2) Sketch of modular dummy design - Wentian Chen
This dummy is composed of one base with a pole and many module parts strung together that imitate human body structure.

First, I need a base that is heavy enough to withstand a lot of impact while maintaining stability. I started investigating in terms of materials, weight, height, stability, and mobility.

There are many materials that can possibly be used for the base: aluminum, cast iron, steel, and stainless steel. Aluminum has a strong resistance to corrosion, excellent mechanical resistance, good cast-ability and weldability. Unfortunately, it has a low specific weight and is not heavy enough to make the base. However, aluminum is an ideal material for the pole.\(^5\)

Cast iron and steel are both ferrous metals comprised primarily of iron atoms. Pure elemental iron is too soft to be useful in most applications. It gets harder, and therefore, more useful when it’s alloyed or mixed with carbon. Cast iron typically contains more

than 2 percent carbon, while steel often contains between 0.1–0.5 percent carbon.\textsuperscript{6}

Cast iron is easier to work with in most casting applications, but steel has an optimal mix of both strength and ductility, making it extremely tough. The impact-resistant qualities and all-around load-bearing nature of steel make it desirable for many mechanical and structural applications.

Corrosion resistance is an important factor in my design because it can’t be eroded by user’s sweat. Both iron and steel will oxidize in the presence of moisture when left unprotected. Even though stainless-steel costs the most, it is still likely to be a better option because it has chromium and other alloys added to prevent oxidation. However, to prevent corrosion, I can paint a coating to protect both iron and steel surfaces.

Cast iron is often cheaper than cast steel because of the lower material costs, energy, and labor required to produce a final product. Raw steel is more costly to purchase, and it requires more time and attention to cast.

When designing cast products, however, it is worth considering long-term use and replacement costs. Parts that are more expensive to manufacture can end up costing less in the long run.

The base needs to extend out and the pole needs to be adjustable to the height of several different users ages 18 and up. Data collected from the Centers for Disease Control show that average height for Americans has stabilized in the past 50 years to about 5 feet 9 inches for men and 5 feet 4 inches for women.\textsuperscript{6}

inches for women. I have also done an experiment myself. I first taped a huge piece of paper on the wall, then randomly asked 30 people, all of a different age, race, and gender to stand against the wall for me to trace them. The results show that the average height of the 30 people was between 5 and 6 feet. This data is consistent with the information online and therefore, the base needs to be able to adjust its height from 5 feet to 6 feet. The average weight of American men from 2015-16 was 197.9 pounds; for women, it was 170.6 pounds. This is the reason the base needs to weight at least 200 pounds or more, to take the hit from its user.

Another way to improve stability, without making it heavier, is to calculate the number and angle of the legs. The lower the center of gravity, the more stable the object. The higher the center of gravity, the more likely the object is to topple over if it is pushed. I can also increase the stability of the dummy by increasing the area of the base, but I still need to test how much floor space the base can take so as not to make people stumble while training. Along trying to find a happy medium, I also studied woodworking and tried to find inspiration in furniture design, to understand how many legs the base needs to be as stable as possible. A three-legged project will not wobble, regardless of slight differences in leg length, because the weight will always be distributed across all three. I also experimented with many different shapes using plastic pipes. I made them into a V shape, triangle shape, cross shape, and three-legged cross shape. The experimental results show that the three-legged support is indeed the most stable.

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To be sure the base is not only heavy enough to take a hit, but also ready for the user to move it around, I need to put a wheel underneath each leg and add adjustable features to the wheels in order to allow them to be exposed or hidden, based on user preference.

The design of modular pads needs to accomplish everything a user could want, without much embellishment. I don’t want to limit the user’s creativity by visually making it look like a human, but each body parts need to physically capture the feeling of hitting a real human body. It will incorporate different hardness levels in different striking areas and that will be based on the materials used for various parts. This is important because it will give the user a more accurate representation of what it’s like to strike an actual human being. Based on the modular method this dummy can be used from 360 degrees, which will create an opportunity for users to practice their foot work and body rotation since the user can attack the dummy from any angle.

I have compared and tested many materials, researched new scientific and technological inventions such as 3D printed synthetic muscle; artificial muscles that

*Figure (5) 3D printed synthetic muscle is up to three times stronger than human tissue. Images © aalan miriyev/columbia engineering*
were made of soft robots or Nylon fibers. Some of the inventions have potential value to help me simulate muscle response. A researcher at Columbia engineering had a creation of untethered soft robots whose actions and movements can mimic natural biological systems. A group in the creative machines lab has developed a 3D printable synthetic soft muscle; an artificial active tissue with intrinsic expansion ability that does not require an external compressor, or high voltage equipment as previous artificial muscles required. An EPFL team also developed soft, flexible and reconfigurable robots. Air-actuated, they behave like human muscles and may be used in physical rehabilitation. They are made of elastomers, including silicon and rubber, and so they are inherently safe.

I finally moved on from the inventions because my goal was to find a material that is not only simulate the human body when hit, but also remain cost-effective. Thinking of Rocky Balboa punching meat at the slaughterhouse, and because this design is based on the feeling of impact, I need to start my own experiment more physical. To do this, I went to different stores such as Lowes and Home Depot that offer different materials so

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I can have a more intuitive feeling of different material, and even take few punches to test them out. Rubber has a reasonable hardness, but it is also too stiff, doesn’t allow air flow, and it does not feel alive. I once tried to punch a tire and the feedback was extremely stiff, and hurt my hands. Memory foam on other hand allows too much air to travel through it, is only good for slow-motion hitting or sitting. It does not perform well with a fast strike because it decompresses too fast and makes the user feel almost like they are directly hitting the post and it does not provide enough protection. Silicone feels the best and gives out wonderful feedback when it gets hit. The existing market already uses silicone to make ballistic gel for knife testing, but the cost of silicone is too high in comparison to other materials and it is not easily mass produced or accepted by the public. After all I decided to go with the packaging foam category, because they were designed to take impact and protect the package, there are still two types of packaging foam, open cell foam or closed cell foam, I need to find the one that has the most authentic feedback.

Although open cell foam and closed cell foam may present similar appearances, they should be treated as two different products as their properties and performance are totally different. Open cell foam (Polyurethane) is soft and breathable, generally more flexible and can more easily conform to sealing applications than closed cell foam, and it will absorb liquids. Open cell foam also comes with both high and low densities, however, it is less durable than closed cell foam. Closed cell foam (Polyethylene) offers a wide variety of material and density options, it is closer to the properties of Styrofoam.

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11 Jenkins, Kadian. “Silicone Seems to Be More Expensive than Other Rubbers, Why Is This?” Why is silicone classed as a premium rubber?, June 2, 2015. https://silicone.co.uk/news/silicone-seems-to-be-more-expensive-than-other-rubber-why-is-this/.
but is much more pliable and flexible. It is ideal for sealing as it effectively reduces liquid and gas flow. After all, closed cell foam is more rigid, and has excellent resilience and durability.

I have gathered different kinds of foam packaging from our daily life, and I discovered Closed cell foam (Polyethylene) has the best material for shock absorption. This kind of foam comes with different thicknesses and densities, and by convolving them layer by layer I can also control each layer’s elasticity. This is important because, layering them up will create a gap between each layer and allow air to travel through, which imitates the growth of muscle having blood flow through each layer. When it takes a hit, it will first try to absorb the power then bounce back, just like how human muscle will react. I was working closely with Lee Davis, a local boxing coach from Rochester, NY, trying to test the feeling of hitting the foam. Lee has many years of practical combat and coaching experience, and he is very familiar with the different body reactions when attacking different parts of the human body. We tried different numbers of layers, different kinds of combinations with different thicknesses and density of the foam and finally figured out the final formula of each body part that can simulate the human body as close as possible.
After finalizing the materials of the base and pads, the dummy still needs a cover for each individual body part, although I like the look of the overlapping foam and visually they simulate the look of human flesh, giving the user an idea of what is underneath the skin. But a cover can protect the foam and make each part more durable. After I compared waterproof cloth, flexible fabric, leatheroid and other soft-goods materials, leather has a similar texture and feeling to human skin and it protects the parts underneath. It is also the most common material for boxing bag covers, because it’s very forgiving and has a lot of elastic force. Leather is also very durable and its texture and touch give the user a luxurious feeling.

In addition to having a good physical feedback, it also needs to have good technical support to provide the user a better learning and training experience. The dummy also has integrated intelligence. Some of the body parts come with pressure sensors that users can connect to their smart phone by downloading the app, this special feature allows users to track their training in a digital way.

There are many impact sensors on the market. A company called “Impact Wrap”\(^ {12}\) used a patent-pending sensor secured outside of the striking area on either the top of a hanging bag or at the base of a freestyle bag. This upgrades the training bag into a “smart bag” that can calculate force, strike count, hits per minute, and provide the user with a complete summary of all workouts.

A team of Cornell students have designed and built their own electronic boxing trainer system. There are five square pads organized roughly into the shape of a human torso and head. Each pad will light up based on a pre-programmed pattern. When the pad lights up, it’s the player’s job to punch it. The game keeps track of the player’s accuracy as well as their reaction time. The sensors are mounted flat against a wall. When a user punches a sensor, it compresses. This compression causes the resistance between the two pieces of aluminum screen to change and the resistance can be measured to detect a hit. The students found that if the sensor is hit harder, more surface area becomes compressed. This results in a greater change in resistance and can then be measured as a more powerful hit.

Everlast, one of the world’s leading boxing equipment companies teamed up with PIQ ROBOT, a sports technology company, in 2018, and designed a wearable sensor that can fit on the user’s

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wristband while boxing. The boxing-sensor system provides the user with real-time action information that will allow them to improve their punches, including speed of punch, G-force at impact, and retraction time. But I see this product as a primary stage testing product, because it’s way too big and inconvenient in my opinion. Imagine fitting that sensor into your glove and training with it, your wrist won’t feel comfortable. I still advocate for putting a sensor on the dummy, thus giving users more freedom.

It’s also necessary to design an app to cooperate with the sensor. The software counts the number and amount of the perturbation from zero and displays this information to the user on a smart phone. This allows the user to monitor punches per minute, max force they’re punches, and endurance over time. It will also need to be able to receive a signal, calculate data, and synthesize a training summary which tells users whether they have reached their training goal.

I also researched motion capture technology, which is a way to digitally record human movements. The recorded motion capture data is mapped on a digital model in 3D software so the digital character moves like the actor you recorded. Motion capture

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is used in the entertainment industry for films and games to get more realistic human movements. In fact, this technology is already very close to us. Five years after the Xbox 360's original debut, the well-received Kinect motion capture camera was released in June 2013, now with the support for Kinect Xbox One, your animations will be more natural and authentic than ever before, you can play many games applied with motion capture in front of your TV.

Kaia Health Software\textsuperscript{17} is a company that develops health and workout apps and tries to help patients in their recovery of pain and in their rehabilitation after specific health problems. The app analyzes the video information captured using the phone’s camera, extracts information about the key points in the user’s body and compares the information provided by the tracking of those 16 key points with the app’s correct preset metrics. This technology could completely change the way people exercise by making it possible to correct their performance for complete exercise programs comfortably from their own homes.

With motion capture technology, it became possible to record the user’s training process and it can let users know if they have the correct body actions.

Design & Model Making

Based on my research and experiments, my new challenge was to build a life-size model that has all the required physical functions, and is also strong enough to withstand the shock when the user takes it for trial. Therefore, I started making the base and pole. I finally chose steel with anti-rust coating to make the base. Steel costs more compared to cast iron, but it is extremely tough and has the ability to take more impact, making it more durable, and possibly end up costing less in the long run. The pole that connects to the base will be able to adjust its height based on the user’s preference. I chose aluminum as the final material of the pole based on my previous research. Aluminum doesn’t contain iron or steel so it doesn’t rust, however it is prone to corrosion when exposed to weathering and atmospheric oxygen. The process of aluminum corrosion is known as oxidation and applying a layer of protective coating to the aluminum surface can make sure it is never exposed to its surrounding environment, thus protecting it from corrosion. Aluminum is also light, has good cast ability and weldability, it is an ideal material for making the pole with an adjustable height.

I found an abandoned heavy-duty camera stand from a photo studio, after looking up the manufacturer, this stand was most likely made around the 1960s, and the look of it is very bulky and industrial. It has a heavy base that is made of cast iron with a layer of an unknown black coating. The base also has three expanding legs, under each leg there is an adjustable wheel that can be exposed or hidden to help the camera stand move easier. Surprisingly, this camera stand is very similar to my ideal base, due
to limited funds, I decided to recycle it and make some modifications based on its existing form. Although I was lucky enough to get this opportunity, there are still plenty of modifications I need to do in order to make the stand into the desired base for my dummy. First, I’ll have to remove all unnecessary parts. I only left the three-legged cast iron base and an aluminum pole attached to the base. The existing pole was way too tall for the dummy, so I had to saw a little part off to fit into the frame for the average user’s height.

Because this dummy is designed to serve different levels of users, starting from beginners, to experienced boxers, to professional fighters. Modular padding will be able to be custom designed for the customer to ensure that the dummy fits each person’s own training style. It will also cover many types of martial arts with standing posture including: Boxing, Kick Boxing, Karate, Taekwondo, and Kungfu.

The pads of this dummy were designed with the layout of the human body in mind. The dummy generally has 6 body parts, the head, shoulder and arm, chest, abs and ribs, thigh, and shank. Each individual part will simulate a real human muscle group and the user will be able to experience the real feeling of actual combat, because my design goal was to capture the feeling of hitting a real human body.

After countless tests and research, I finally decided to use closed cell foam (Polyethylene) as the material for bionic muscles, because it presented the best performance of shock absorption. Combined with the test data, I worked out a formula including the combination of foam with different thicknesses and densities, number of layers, the tightness of the bundle and the gap between each layer that mimics the feeling when impact is applied to each body part. No more passive dummies like BOB,
this dummy could actually create more interaction and feedback. It will incorporate different hardness levels in different hitting areas based on the materials used for various parts. This is important because it will give the user a more accurate representation of what it’s like to strike an actual human being.

Users have different levels of skill and experience and based on the user preference, we can guide the user to order individual parts online and put together a dummy that is particularly designed for their level. There are many levels of experience options: elementary, experienced, advanced, professional, and ultimate fighter. The individual body parts will be specific for the user experience level. The varying pieces based on the user make for more interaction to help each user feel a much more personal training experience. The user could concentrate on the imitation of actual combat and enjoy the training experience.

This free-standing dummy has no environmental limitations. It will not be limited for use in one area, such as leaning against the wall or hanging from the roof. This means that this dummy is designed to take impact from all sides, and it has an unlimited attack area. By creating a 360° boxing dummy I allowed a maximum of three users to share it, training from three sides. Training could become a game or a competition for users to compete with each other. I discovered this wonderful accident, one time I asked my friend to test out the pads, but I forget to lock the wheels. After he threw a punch, the dummy went rolling in my direction and I kicked it back to him. After that, we started to
compete to see who punched faster and harder and pushed the dummy against each other. The experience inadvertently added game attributes to the product, when you lower the wheels and allow the dummy the ability to roll, three users could see who could strike with the most force and efficiency. The objective is to keep the dummy the farthest from you and not allow your opponents to pin you to a wall or corner. The game would incorporate all parts of the dummy and utilize them in a way to outdo your opponent.

To create more interaction, I added a swing arm attached to the shoulder. I got my inspiration from Quintain, a medieval martial arts training device. I also want to give life to this dummy by offering a chance for him to defend himself and hit back. Other dummies on the market do not have this option and it will set it apart from other competitors. This feature is important because it can train the user how to dodge, block, and strike back. It will also encourage the user to be nimbler with their footwork. It could also be a game between users when they are sharing the dummy, one user can set up the other by hitting the swing arm, and the other user could dodge or block the arm and send it back to the first user. The swing arm could swing one way or another. The user has to be highly alert which will help training the users reflexes, making them respond to an attack faster and more accurately.

In order to protect the pad from being scratched, I chose to design a leather cover for each part, so as to increase the service life of the pad. Leather has a certain degree of tension and water resistance, as well as comfortable touch. However, compared with most fabrics, leather is more difficult to sew because of its thickness. Leather has high requirements for sewing machines and sewing threads, it requires an
industrial sewing machine and heavy-duty needle and thread. Each muscle module will have a different color cover based on the hardness of the muscle group. As for the choice of color, I refer to the color psychology. The psychology of color is based on the mental and emotional effects colors have on sighted people in all facets of life. Color is often associated with a person’s emotions and it is consistently used in an attempt to make people hungry, associate a positive or negative tone, encourage trust, feelings of calmness or energy, and countless other ways. I chose to use different types of blue as my brand color because it shows calmness, humble and wisdom, they are the key theories of all martial arts. As kung fu star Bruce Lee once said: “Do not be assertive, but adjust to the object, and you shall find a way around or through it. Empty your mind, be formless. Shapeless, like water.” The highest level of martial arts is not just a physical move, but also uses wisdom to solve all problems. I also chose

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yellow as my secondary color; yellow makes people feel cheery and warmth. Adding a popping color can also motivate users psychologically and I want this dummy to stand out in front of all the training gear on the current market.

After completing the design of the hardware, due to limitations of ability, time, and money, I couldn't make my model a “small dummy” but I still like to plan the technology features of this dummy, and entire training system base my research on the existing technology products. This training dummy will have both a built in and external coaching system, each modular pad could have one or as many as needed for the number of impact sensors built into it. These sensors can measure the user's overall training status, including the speed, strike force, hit point accuracy, training duration and training quality. Having the sensors connect to user’s smart phone though an app is the simplest and most intuitive way to present data. The app can also teach users how to box, correct improper posture and technique, give feedback, and motivate the user.

The use of motion capture technology can be more intuitive to let users see their training actions. I would team up with professional coaches, the coach can upload training courses for users to download. The training course would show ghost shadows that would teach users the right form and correct the user's body movements. I also want to work with well-known professional boxers, UFC fighters, action movie stars, even the late legends such as Bruce Lee and Muhammad Ali to make simulation ghosts shadows for users to learn from the stars.

Along the progress of training, users could also graduate and move up from one level to another, the app will review the user’s progress based on the data and carry out upgrade suggestions or revise training plans. Doing this will increase the interest and
motivate the user to train harder, creating a fun and interesting environment to help the user to achieve their exercising goals. This would encourage users to share the video to social media. It would build up a community space for friends that allows them to share their training results, photos or videos to compete or motivate each other. By doing this I’m not only motivating my user to have better training results, but also creating great advertising and promotions for this company and this product, because I believe social media is a strong weapon in the marketing world.

Summary & The Future

Being able to custom design your own dummy could be the best fit for users to achieve their training objectives. Having the option to easily adjust the height makes the dummy applicable to more people, and have different hardness levels, different materials and different areas of striking surfaces makes the dummy perfect for any type of training. This dummy is cost-effective because it is easy to replace parts and there is no need to buy a whole new dummy if something were to break. The product itself might be expensive to make, but with the ability to change out individual parts, it is still cost effective for the user in the long run.

Different parts will have their own hardness, texture, and density, but also keep the consistency of the design. The different parts visually encourage users to hit the dummy by implied usage of color and texture, shape, area size, and hardness. This will ensure the surfaces are safe for hands and not easy to break.
Possible technology supports could help this design not only having a great physical experience, but also visually helps and motivates users to improve the user experience in both ways.
References

Ballistic Dummy

Artificial Muscles

Modular Design

Bearings

Stainless Steel vs Cast Iron
Packaging Foam


Impact Sensor


