Criterion A: Inquiring and Analyzing

Explaining and Justifying the Need:

Within a rapidly developing world, technology is being more depended for daily lives. The technological advancements that exist such as smart phones, tablets, laptops, portable game devices are relied on for work, sending and receiving emails, documents, social media, and more general entertainment such as YouTube videos or listening to music. With these devices being so useful and integrated into daily lives, people tend to move them around and make such electrical equipment used in a portable fashion. With the outdoors, cafes, parks, and other areas not necessarily providing electrical outputs or chargers, these electrical devices will run out of battery or electrical charges needed to run them, because the overuse of these devices through videos over extended periods of time will lead to increased consumption of power, leading phones to switching off easily. This problem mainly occurs with teenagers and young adults as they are "the generation" to be extensively dependent on smart technology. Moreover, this is a problem as charging these devices lead to a more passive and less active lifestyle while charging phones, laptops and etc. which adds to the problem by reducing the healthy lifestyle. Once again the problem is caused by the increasing dependence and application of smart technology systems, which leads to the reduced health through less active lifestyles and device batteries constantly being drained.

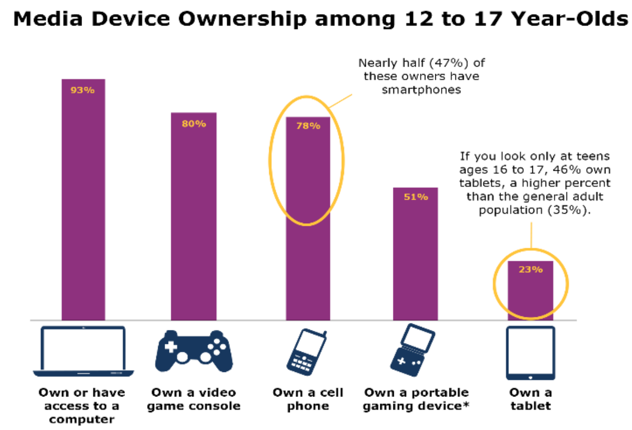
1. Nearly two thirds of Americans own smartphones
2. 46 percent of smartphone owners "couldn't live without" their smartphone
3. 36 percent of smartphone owners would choose their phone over their TV

4. 87 percent of millennials say their smartphone never leaves their side

5. 80 percent of millennials say their smartphone is the first thing they reach for when they wake up

6. 60 percent of millennials believe everything will be done on mobile devices in five years.

7. More smartphone owners use their phone for watching videos than playing music



Source: https://www.hhs.gov/ash/oah/news/eupdates/images/mediausedeviceownership.png

As seen here, these statistics therefore lead show a high amount of dependence on electrical devices such as phones and laptops. It is this increased reliance, especially outdoors that lead to a continuous loss in 'battery life'. The highest % of users have been found to be teenagers up 46% own a media device. ("13 Crazy Statistics about How People Use Smartphones." *Wainscot Media*. WAINSCOT MEDIA BLOG, 12 Nov. 2015. Web. 14 Dec. 2016. <http://wainscotmedia.com/blog/13-crazy-statistics-about-how-people-use-smartphones>.)

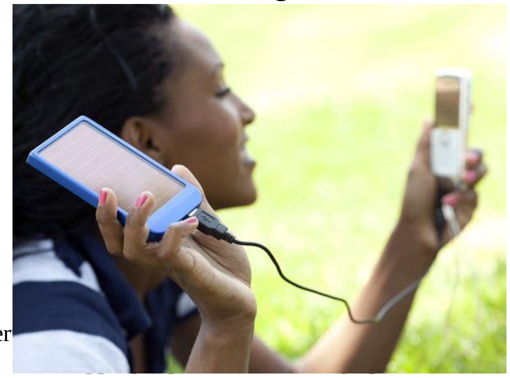
Signs of Constructive Discontent

Adhiya, Dhvanesh. "Best IPhone Power Banks: Portable Chargers to Keep Your IPhone Powered Up." *IGeeksBlog*. N.p., 02 Dec. 2016. Web. 16 Dec. 2016. <https://www.igeeksblog.com/best-iphone-power-banks/>.

Power Bank/ Portable charger:

It is apparent here that a simple power bank is a good source to passively charge electrical equipment such as iPhones and iPads as apparent here. Having an external and lightweight power source acts as a method to passively store electricity charged by any other means (power source at home). As a result, a portable charger can sufficiently charge a product (quickly too) without the user being necessarily active. The chance of phones shutting off due to no battery life is heavily minimized. However, the product is not made for those who extensively remain outdoors or head home much. As a weakness, the portable charger relies on the user consistently taking the time to wait for it to be recharged and relies on the presence of sockets in a variety of places to recharge. As a result, it is more of a passive means of recharging equipment, rather than being a sustainable long lasting power generator. (Limited sustainability as power banks/ portable chargers technically 'store' electricity generated rather than produce it). Finally, as charging holes are limited in number and shape, not all laptops and phones can be charged using a power bank (depends on device model) despite the diversity in portable charger design, and current flow.

Solar Phone Charger:



Rober

Guide." *National Geographic*. N.p., n.d. Web. 16 Dec. 2016. <http://environment.nationalgeographic.com/environment/green-guide/buying-guides/solar-charger/shopping-tips/>.

To portable phone chargers or power banks, solar chargers also come in many sizes, shapes and designs, as well as electrical outputs (solar energy harnesses and power supply in mAh, or milli-ampere hours). As accessible devices, it is common among people who go camping or hiking to use solar chargers. These devices can be seen as passive generators of electricity, as they primarily rely on the presence of sunlight in outdoor areas to maximize the amount of electricity photovoltaic cells can produce over time. The function of solar chargers is also their main weakness, meaning that they can only rely on light as an energy source, almost forcing users to track sunlight when battery life is low. Although environmentally friendly, a solar charger rather tends to be more expensive (especially when size and build quality is taken into consideration) as photovoltaic systems are expensive (much like that of massive solar panels). Moreover, they are not suitable to all weather conditions and regions (colder regions will not have bright light, winter has less sunlight as the earth is further away from the sun in winter than summer as well as taking in consideration the formation of clouds) and is near useless during nighttime. Therefore, a sustainable solar charge is very situational in purpose, despite it being capable of generating and storing electricity passively. However, as solar chargers generally do not many holes for charging, only select electrical equipment can be charged (e.g. three pronged socket chargers cannot be used).

From here, most portable chargers passively gain their electricity, but rely on circumstances such as the presence of sunlight or charging stations (sockets). High quality products like these can therefore, aid in solving the problem, yet create new problems. For example, a power bank needs a charging source of its own, while solar chargers need the continued presence of the sun to maintain function.

An **interview as expert appraisal opinion** has been conducted with an electrical engineer in order to collect data to understand that there is a solution to a need. I have asked him about his experience; he responded by notifying me that he involved himself in projects to reach sustainable solutions like programming a greenhouse and has programmed drones and other unmanned vehicles, therefore familiarizing himself with electrical concepts needed to charge phones and other devices.

1. Due to increased dependence of societies on phones and laptops, do you see that battery consumption is an issue especially for those who go outdoors?
2. If so, would a solution be helpful (such as a long lasting electrical energy generating product, compared to that of portable chargers)?
3. Response:
   A. “Definitely, with technology being rapidly developed, more people seek entertainment and rely on electronics for social network. As with all electronics, phones and laptops get switched off easily when they are being used too much as electricity is drained, where it is being consumed faster than recharged. Yes this definitely is a problem.”
   B. “A solution is very helpful indeed. The issue with solar chargers and portable chargers is they too need to be charged for them to keep functioning. A long lasting electrical energy source should have some form of external and consistent work input itself. Dynamos rely on kinetic energy for example to supply this energy such as cranking or wheels on bicycles. Different mechanical systems can be used for this innovation.

   From the interview, statistics, and constructive discontent, a solution is needed to address the need. This need is to be addressed through the global context of scientific and technical innovation. A long lasting portable electronic charger needs to be innovating by synthesizing physics, electrical engineering, and mechanical systems. The ingenuity and creativeness needed comes by adapting human kinetics and existing mechanical systems to make a product that progresses present solutions. For this product to be adaptable, it would need to be comfortably used by users and have a form and design to match anthropometric related needs. An adaptable product would thus maximize comfort and ergonomics.

Research Plan:

What do I need to find out/learn?	**How will I gather this information? State whether primary or secondary source**	**Why will I gather this information? Why is it important?**	**Priority (Highest 1- 5 Lowest) Rank your research areas according to their importance to helping you Design a suitable product.** **When? (Specify date and order of your research)**
Analysis of case studies of similar and competing products in the market to look at General function and design of electrical energy generating devices (active conversion of kinetic energy)	Primary and secondary source- case studies using SWOT Analysis.	It is needed to understand the material, form, design, and manufacturing techniques that these products use in order to heighten my general understanding and knowledge. Comparison of different examples locally and globally- cost analysis in the market.	5-An overview in order to understand needed techniques and design features for rechargeable products as well as products in the market. 28/11/2016
Research into electricity and current physics	Primary source- Interviewing an expert such as an electrical engineer in order to know needed concepts and know what to research Secondary source – Internet	The interview allows me to understand the mandatory concepts on a deep level rapidly and needed laws to apply, while the secondary sources can allow me to further my knowledge to an analytical level.	5- Mandatory- It can be combined with knowledge of mechanical systems. It is important the power is high enough (decent amount of voltage and current needed). 7/1/2017
Mechanical systems to generate electrical energy.	Primary source- Within the same interview needed for current electricity Secondary sources- diagrams, explanations on the internet.	The kinetic energy generated by the user will need a system in order to convert into electrical energy through a dynamo.	5- The innovation and ingenuity relies on a mechanical system for continuous generation of electrical energy while on the move. The primary source introduces the right systems, while secondary is needed to further my research. 7/1/2017
Ergonomics- handles, and pedals, cranks.	Secondary source- Anthropometric data of hands, handle ergonomics and comfort, Pedal design. Primary source- ergonomics expert needed for specific design features to increase ergonomics, reduce physical stress, and allow adjustability.	As adjustability, ergonomics, and adaptability of the product is essential for innovation and increased, ergonomic factors can affect the designs, while anthropometrics can affect the necessary dimensions.	5- Key part of global context heavily influences design. 9/1/2017
General design features-	Primary research- Survey with young adults to adults (both males and females).	Know the features needed to be implemented on the product by the target market, predicted cost (feasibility), aesthetics, and specifications.	4- Reduces confusion. Determines suitable aesthetics needed such as the design style (sleek, etc.) and the best color combinations. This heavily influences the design and manufacture as an outcome and guides work. 9/1/2017

Materials and manufacturing techniques	Primary- Expert interview. Information on best type of material to use for manufacturing based on physical qualities, mass, availability and easiness to use. Different materials will lead to different methods of manufacturing.	Finding the best materials to work will affect what components will be used, affect the specification requirements and support the function of the product. And most detailed form of manufacture is needed to produce a high quality product to satisfy target market needs.	4- The materials would affect the means of manufacture, would affect dimensions, shapes cut, and overall affects the product’s safety. Materials need to satisfy the function and support it. 8/1/2017

Analysis of Existing Case Studies

ducts." *K-TOR*. N.p., 16 Sept. 2013. Web. 20 Dec. 2016. <https://www.k-tor.com/ktor-products/>.

K-Tor Power Box

Strengths:

- Universal charging station. Works incredibly well with phones, laptops, radios, cameras etc.
- Foldable and designed for disasters, blackouts, and used for bringing dead electronics back to life through pedals that spin the dynamos.
- Spontaneous rechargeable system outperforms solar chargers
- Can be used for outdoor by campers, and hikers in rural areas.
- Double pedal means that many revolutions can be performed while seated, generating power comfortably.
- Emergency badges for safety.
- Can rapidly generate 20W of power making it able to sufficiently charge larger electronics.
- Strong polycarbonate plastic.
- Stores electricity for extended periods of time.

Weaknesses:

- Bulky to carry around.
- High surface area, even when folded, won’t fit in compact spaces.
- Pedals are not adjustable, can be too large to people with smaller feet, and can be too small to some.
- Needs flat surface, (not found in rugged terrain in nature).
- Adjustable only through screws.

Opportunities:

- Should be adjustable without screws, in order to maintain needed portability during disasters.
- Retractable or detachable parts would allow for compact carrying
- Design can take consideration of feet ergonomics for the pedals (adjustable if possible, to allow easier pedaling).

Threats:

- Carrying it places pressure on back, hands (depends on how it is carried) which causes pain

ducts." *K-TOR*. N.p., 16 Sept. 2013. Web. 20 Dec. 2016. <https://www.k-tor.com/ktor-products/>.

K-Tor® Pocket Socket 2
Strengths :

- Generates up to 10watts of electricity at 120 volts. This is enough to power most hand held devices such as iPhones.
- Comes with emergency yellow graphics (safety, not apparent here)
- Ergonomic crank allows for rapid generation of electricity up to 120 RPM.
- Foldable product, making it fit bags and pouches without the crank being an issue (with a pommel)
- Dimensions: 63.5 mm x 5.65 mm x 174.625mm. Small for most bags and some pouches
- Lightweight: mass at 425.2 grams. This allows for portability in most areas, which makes it useful for disasters and outdoor situations (like camping, walks, hikes)

Weaknesses:

- Any form of over accelerated cranking can cause a current too high that can overheat and overload the product causing, a heat buildup and product failure.
- The crank does not seem to support larger hand sizes despite pommel (low width). Fingers would need to be removed.
- Appears to be too wide (overall product), will not fit tighter pockets (such as that in jeans).

Opportunities:

- Overall upgrade to cranking limit to maximize current and increase power supply
- Crank handle should be adjustable to suit more anthropometric needs (larger hands).
- Can be narrower to fit pockets and add portability and easy accessibility.

Threats:

- Can break into sharp bits if it falls from a noticeable height.
- Overheating means temperature build-up which leads to potential burns if poorly insulated
- When camping, nearby moisture of any sort can enter charger hole and lead to electrical shocks.

The Voltmaker

. "Voltmaker - The World's First Smart Charger." *Indiegogo*. N.p., 26 May 2013. Web. 16 Dec. 2016. <https://www.indiegogo.com/projects/voltmaker-the-world-s-first-smart-charger#/>.

Strengths:

- Weight: Approximately 300 grams. Very lightweight, allows for easy portability without any pressure on back (or carrying it).
- Size: 15.5 cm (length), 3.6 cm(diameter). Very compact, as cylindrical design can easily fit pockets and even slide into pouches easily. Foldable crank minimizes unneeded surface area.
- Sleek and circular design allows it to be very adaptable as most electronics are progressing towards sleeker designs.
- Charged through battery or cranked. Battery is 2,000 mAh lithium ion battery.
- Charges most smaller devices at 5V (input and output), like phones.
- Aesthetically pleasing, as it is glossy with a wide range of colors

- Customizable (allows for flashlight modification).

Weaknesses:

- No Pommel and thin design of crank can lead to slip (especially with those who have sweatier hands) despite the crank supporting most widths.
- Would not charge devices that require more than 5v like some tablets and laptops.
  Opportunities:
- A Voltmaker can be designed with a socket for more voltage (both input and output) with a larger battery for more extended use with laptops
- Rubber grip, more cylindrical crank with considerable diameter to avoid slip, and maintain grip.
  Threats:
- The rectangular like grip can lead to sore hands. The compact crank can lead to lots of pressure over a small area (device diameter) can hurt nerves if cranked too quickly over time. Hands can be hurt. A cylindrical crank is the solution.
  Threats:
- The rectangular like grip can lead to sore hands. The compact crank can lead to lots of pressure over a small area (device diameter) can hurt nerves if cranked too quickly over time. Hands can be hurt. A cylindrical crank is the solution.

Hand Energy

"HandEnergy: Your Pocket Electricity Generator." *Kickstarter*. Kickstarter, n.d. Web. 16 Dec. 2016. <https://www.kickstarter.com/projects/handenergy/handenergy-your-pocket-electricity-generator>.

Strengths:

- Average speed 5000 RPM. The magnetic rotor transmits mechanical power to the stator and produces an electric current, charging the built-in batteries.
- Can charge phones, e-books, smartwatches, and flashlights at an output of 5V at 1A.
- The circular motion of the hand causes a centripetal force which produces current through transmission of mechanical power. This produces clean energy powered by human kinetic energy.
- Small enough to fit bags, purses, etc. Dimensions: 70.7mm height, 72.8mm wide.
- Flat top and bottom makes it easier to hold to hold and place on surfaces.
- Aesthetically pleasing with designs and patterns, is an example of progression of modern tech. Adaptable as it is part of the emerging sustainable technology to combat climate change and gas emissions from fuels.
- Contains battery indicator and stores electricity (useful for areas with limited power grids).
  Weaknesses:
- Cannot fit pockets, relies on presence of bags.
- Can slip when rotation is high combined with moist hands or surface if not held properly.
- Continuous user hand activity required for function.
  Opportunities:
- Increase efficiency (less hand movement for power generation).
- Rubber top and bottom for increased grip.
  Threats:
- Continuous wrist flicking and rotation can hurt nerves over long times. Total dependence on it would be exhausting.

Bike Charge

t BikeCharge Dynamo and Bicycle USB Charger : Sports & Outdoors."*Amazon.com : Tigra Sport BikeCharge Dynamo and Bicycle USB Charger : Sports & Outdoors*. Amazon, n.d. Web. 16 Dec. 2016. <https://www.amazon.com/Tigra-Sport-BikeCharge-Bicycle-Charger/dp/B00OMSYR9Q>.

Strengths:

- two USB ports that provide 3W of 5 volt DC power
- Product is used on bicycles. The power is generated by riding the bicycle and pedaling, regardless of any direction. The rotation of the wheel generates the current (wheel and axle).
- Applicable to bikes, rather than being a bike design
- Dynamo can power lamp for night time,

Weaknesses:

- 3W of 5 volts is too inefficient to generate power for phones rapidly. Completely charging a phone would need 2 to 3 hours, which is too long.
- A speed of 12 mph needs to be maintained for it to work, which is not likely.

Opportunities:

- Power need to at 10 W or more, volts need to be doubled or more to increase efficiency
- Speed required for it to work needs to be minimized
- Minimize current sent to lamp while maintaining brightness can allow for the majority of the current to phones.

Threats:

- Charging phones and riding can stimulate users and bike riders to use their phone while riding or keep checking which can distract and lead to a crash.

Research Analysis: General function and design of electrical energy generating devices (active conversion of kinetic energy): The analysis of existing case studies allowed me to understand the general function and technical systems integrated to allow them to be functional. All forms of mechanical energy produced by the body can be considered as clean and sustainable energy as no input finite resources are applied, and because energy can be created faster than they can be replaced. Devices like these primarily target phones and smaller hand held devices, as they tend to supply 5V and are attached primarily via USB cable. The mechanical systems are connected to generators such as dynamos in order to generate this power. 4/5 products analyzed can 'bank' the power over time. Furthermore, the voltmaker shows the possibility that a direct current from a socket can be used as an alternative to constantly cranking, which reduces any prolonged amount of cranking. A parallel series can be established for products to be multi-functional (flashlights). The mechanical systems define the function, features, and the form needed for users to adapt to kinetic chargers.

Current electricity and mechanical systems: It can be noted that the products above on dynamos and motors to harness mechanical energy into electrical energy. Dynamos ideally are generators as they convert kinetic energy applied to electrical energy. This is explained through Faraday's Law of induction which states that the "Any change in the magnetic environment of a coil of wire will cause a voltage (emf) to be "induced" in the coil." (Hyper Physics). To further simplify, the presence of a coil in a magnetic field will lead to a generation of an electromotive force and current if any form of kinetic energy and movement is applied to it. The electromotive force is the energy provided by the source divided per unit charge (charges are measured in coulombs). The equation is:

$emf = \frac{-N\Delta\phi}{\Delta t}$ Where N is the number of turns, ϕ is the magnetic flux= BA. B is the external magnetic field, and A is the area of the coil. It can be deduced that the emf relies on magnetic field strength through stronger magnets, the number of coils to generate current, and the number of turns. The emf can be stronger when more mechanical energy is applied. Research has shown rack and pinion gears can be applied to a shaft and move a coil. The pinion (a gear) moves along the toothed surface of the rack. The rack thus moves in the opposite direction. Any pull or push exerted on the pinion can transform circular motion into linear motion for consistent power production. The wheel and axle system relies directly on circular motion of the wheel and spontaneously generating electrical energy and turning the coil. The simple crank spins a shaft which in turns the coil. The design determines the use of legs or hands based on ergonomics.

In terms of <u>ergonomics and materials,</u> the materials should be lightweight and safe so as to insulate and protect users against circuitry. To allow the design to be compact, it is best suggested the circuit is established first and then enclosed using a 3D printer with ABS (strong and light), biodegradable plastics for sustainability such as PLA. CNC routers can be paired with acrylic for a lightweight plastic manufacture. Ergonomics led to selecting power grip handles for maximum power, in which the fingers and thumb are wrapped around the crank handle.

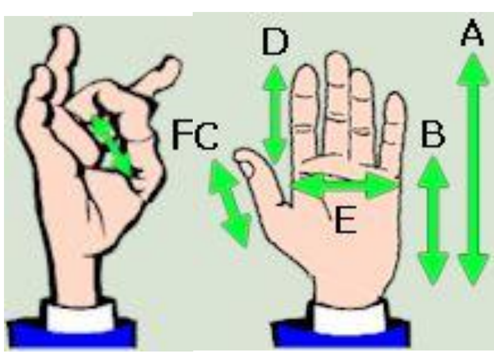
(Source :http://www.ergonomics4schools.com/lzone/tools.htm)

Anthropometric estimates for British adults aged 19-65 years (in mm, from Pheasant)			
Dimension	*5th %ile*	*50th %ile*	*95th %ile*
A Hand length	173	189	205
	159	174	189
B Palm length	98	107	116
	89	97	105
C Thumb length	44	51	58
	40	47	53
D Index finger length	64	72	79
	60	67	74
E Hand breadth	78	87	95
	69	76	83
F Maximum grip diameter	45	52	59
	43	48	53

MALE FEMALE

<u>Features and cost by target market:</u> The survey determines the target market's requests and features, which affects manufacture, form, as well as materials and aesthetics needed for manufacture. They see that a solution to address is a device that can generate electricity passively, without too much involvement. They best see it as multi-functional to add to its usefulness and charge as many devices as possible. Versatility is necessary as it provides the product with as much usefulness as possible in tackling the issue. Moreover, portability, low weight, and size are key as the target market does not want to "lug" the product and keep holding on to it. It must not be a chore or too tiring to operate it, and would be best seen being manufactured with modern techniques that emphasize on curves and smoothness, as well as being colored with modern paint patterns (orange-purple, blue-black, green, matte and glossy appearances) as it modernizes and allows the product to be high tech.

Figure 1: Hand Anthropometrics, Breadth would affect width of handle, length for diameter.
"HAND ANTHROPOMETRY – From Leonardo Da Vinci to NASA & US Army!" *Palm Reading Perspectives*. Palm Reading Perspectives, 28 May 2011. Web. 16 Dec. 2016. <https://palmreadingperspectives.wordpress.com/2011/05/29/hand-anthropometry-from-leonardo-da-vinci-to-nasa-us-army/>.



The width of the hand will tell me how my design will need to be designed so that the portable electronic equipment can be designed in a way for easy handle and grip based on 50th and 95th male hand breadth E 50 mm to enable larger users to use it comfortably with a maximum grip diameter of 50 mm

Rubber is much easier to manufacture than curved grooving lines for fingers, and should have a diameter that gradually increases to comfortably fit fingers without nerve pain or wrist pain. Handles must be cylindrical and match no less than 50th percentile female and no greater than 95th male (hand breadth, length, circumference, overall height), while pedals are preferably to larger percentiles with straps for tightening as the user sees well. Pommels are helpful for removing slip by enlarging the end of the handle and maintain grip and control. Finally, maximizing torque for power (Torque= force x distance around an axis) Must not have a force too high otherwise mechanical energy required would reach levels of exhaustion. The solution is a microwave oven motor from a microwave can generate 220V which can be reduced to any required with transformers. A turntable motor hub under would allow for easier rotation and spinning, therefore increasing the distance and torque using a low force.

Design Brief:

Intended outcome: I am going to design and make a portable electronic equipment charger that relies on kinetic energy mechanically produced by the human body. The product is to use a dynamo to generate enough power to power phones, tablets and laptops. It should be three socketed in order to allow for as many types of equipment to be charged. Based on gap in the local market as established in the description of the design situation with young adults 46 % relying on using electronic chargers on the go.

The target market for this product are young adults to adults of both males & females. The analysis of the design situation as well as online statistics gathered has shown that the need is not specific to any category, but rather shows that a large percentage of the world has become reliant on technology, and thus the target market is to be as expanded as much as possible. Young adults (teens) & adults are the category that use social media the most 46 %, conduct many phone calls & rely on the presence of high tech more so than children & elderly.

Research has shown that emphasis on **portability, low weight,** and **compactness** is key to addressing the target market's needs. The mass of the charger should range from no less than 0.3kg to no more than 0.8kg, in order for the target market to not be bothered and slowed down by it. The product should have a **minimum length of 15cm to fit components,** and no longer than **50cm maximum when folded and adjusted to the lowest setting**, so as to fit a standard backpack, and 5cm wide minimum and 10 cm maximum.. The **maximum possible height** of the product (depends on idea) is no greater than of **30cm.** These dimensions are correlated with features like portability and compactness that the target market requires. The most efficient means of energy generation should follow that of modern products and **synthesize mechanical systems** with the presence of the **coil turning,** for a current (Faraday's law); this can be done through **a rack pinion (loud however, yet leads to linear motion), wheel and axle simply from the wheel's rotational motion** when walking or pushing a wheel, or crank/ pedal which relies on circular motion of the hand. Most products to charge phones generate 5V, while this product should generate no less than 50W at 10V minimum. The handle must have a **rubber grip**, be cylindrical, and have width based on the hand breadth of no less than 50th percentile of female and no greater than 95th male. Manufacture is to be done with **plastics** for their **insulating properties,** low weight, specifically **ABS, PLA** through **3D printing and acrylic using CNC** if needed.

A limitation would be the limited experience with practical circuitry, so as to connect wires efficiently. Another limitation is the inexperience with 3D printing, as well as the high costs required for it, which may allow me to resort to using workshops and hand crafting the product. Managing my time for surveys and experts is a challenge, as it must not conflict with the pace of work nor slow me down.

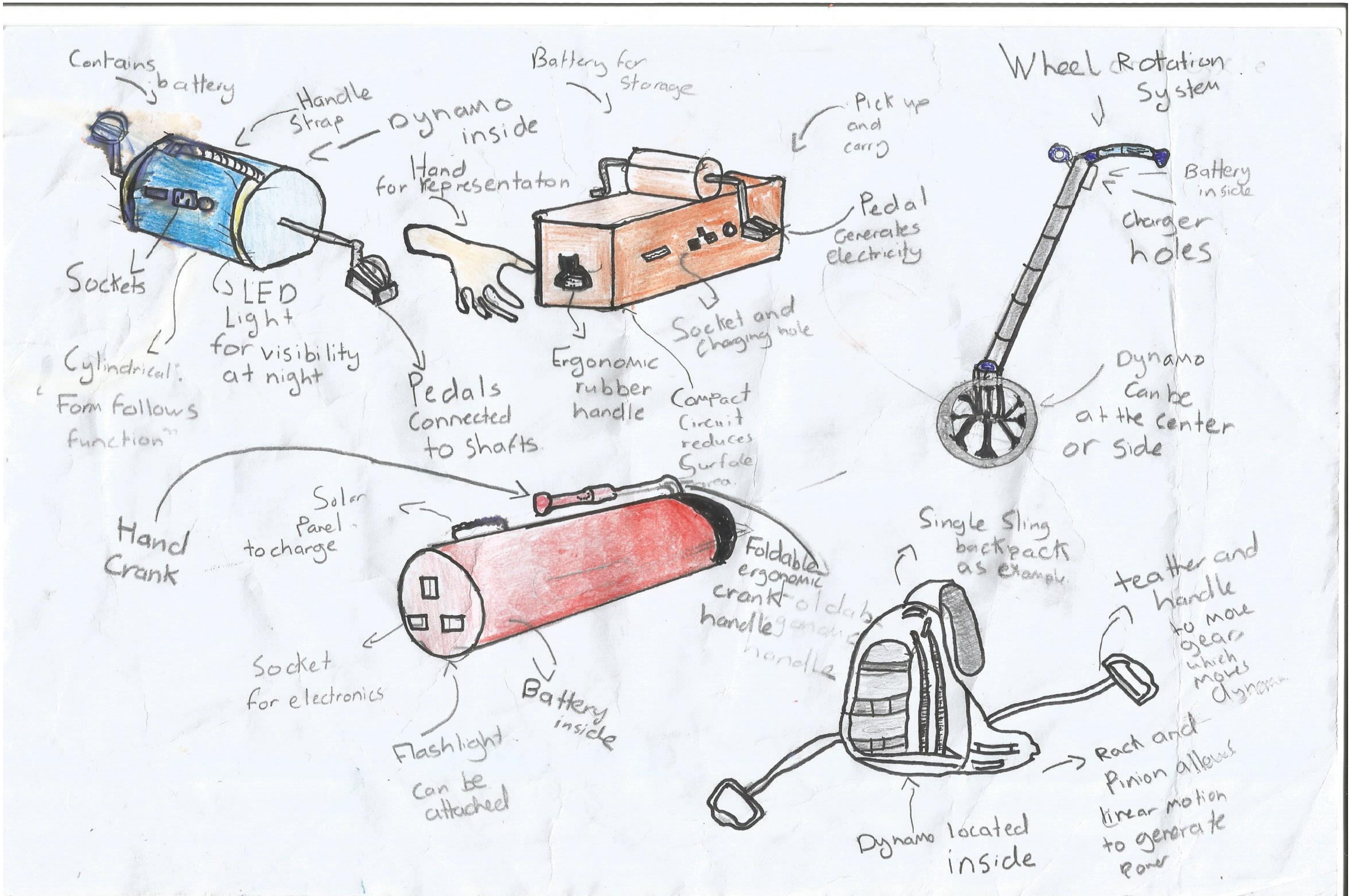
Finally research has shown that the product is best between a range of **$20-50$.** The price is explained by the circuitry, **3D printing costs are high** if the project was produced at batch scale of production, as well as the fact that costs to **generating sustainable energy** for a long period of time should not require unaffordable costs to users in order to maintain **accessibility** to the vast target market, whom have already spent much on **technology.**

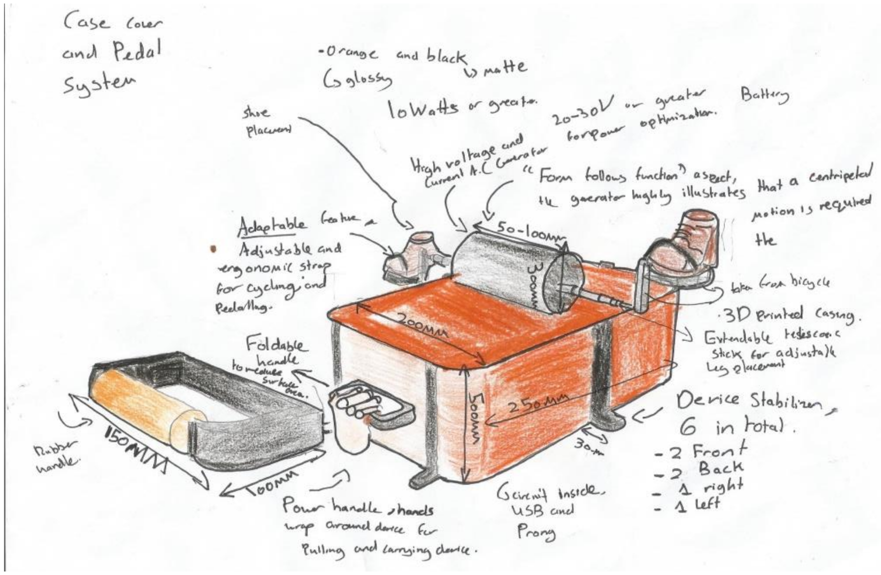
Design Specifications: Must be specific, measurable, achievable, realistic and testable

Specification	**Explanation with Justification and tests.**
Function (efficient power generation and charging)	Generate high amounts of electricity from mechanical energy applied, in which a current will charge phones, laptops, and other equipment. The voltage must be no less than that of 10V, and is preferred to be high as high possible for the most efficient power generation of phones and tablets (10W). Power is measured by multiplying the current and voltage, which can be recorded with an ammeter and voltmeter. Mechanical systems like crank, pedal and shaft, or wheel and axle can convert mechanical energy.
Materials	Must be light weight to correspond with portability and comfort points. Low weight is needed to allow the target market to adapt to movement for spontaneous power generation. Metals are avoided (unless used to rigid cover or telescopic poles out of existing materials (like stainless steel from selfie sticks). Manufacture corresponds to material, where PLA, ABS, or PVA are used for 3D printing with preset colors, or colored acrylic for a CNC router.
Manufacture	Circuit is established including the needed wires dynamos and sockets, then modern high tech manufacturing methods such as a CNC router or 3D printing are used for aesthetics, insulating, and encasing the circuitry with preset colored plastic. Manually cutting out materials would take more time. Manual fabrication would result in more human errors, modernized systems like 3D printing would be less faulty and more professionally fabricated, however household items would reduce the production time, difficulty, and cost of the prototype, which is preferred as it simplifies the process, and relies on adapting from the surroundings to progress and demonstrate engineering ingenuity. Quality assurance and checks will be done to the printed components, but marking out the dimensions, and fabricating the material would rely on design software. Color combinations are implemented into the designs. The final product is then polished for a glossy effect. Rubber is cut out and wrapped around the handle for ergonomics. Modifications like flashlights are added last. Pedals and handles are also 3D printed.
Compactness (Dimensions).	Minimum length of 15cm to allow spacing for hands and components to fit in, no longer than 50cm, no wider than 30cm when fully adjusted to minimum length and folded in order to fit an average backpack used by the target Market. Handles are to be no less than the 50^{th} percentile of females in regards to hand breadth, circumference and length, and no larger than the 95^{th} male percentile. Measurements of each components are made and designed to the minimum. Product width must be no greater than 30cm in order to fit a standard backpack. Note: If the product is to be used in a horizontal position, then the height is no greater than 10cm.
Mass and portability	Mass no less than 0.3Kg (minimum including circuit) and no greater than 0.8Kg. A heavy weight would steer the target market away from adapting to active movement for energy generation. Furthermore, heaviness goes against the market's needs, and conflict with ergonomics, which would create an unwieldy product that is difficult for the target market to adapt to and be comfortable.
User/ Target Market	Young adults to adults of both genders, male and female. Ergonomic features, aesthetics, and anthropometrics are specifically towards the target market, specifically those who use phones and laptops specifically.
Ergonomics (comfort)	Anthropometric measurements applied to handle (min 50^{th} female percentile, maximum 95^{th} male for hands). Compactness and low weight are to minimize burden of carrying.
Safety and Environment	To be used in urban and rural areas(optional, forests and nature e.g), and is hand held and can fit in pockets if small enough and in standard backpacks if large enough. This avoids continuous occupation of the user's hands. Plastic manufacture is to be curved (protection against edges), insulate electricity and protect user from heat build ups and the electrical currents. Device can be set up & manned in even roads or rugged terrain easily
Aesthetics	Detailed fabrication that includes sleek curves, as well as polished and glossy surfaces with modern and bright color patterns (blue and black, red, orange and purple, etc.) chosen through CAD software.
Cost	$20-50 (US). The users dependence on technology is an expensive lifestyle that relies on high quality systems. 3D printing and precise fabrication would be costly at a massive scale, taking into consideration the long term energy generation. This is counterbalanced as the demand for clean energy and

	accessibility would be hindered at high costs, which mean less sales.

Initial Ideas:





X Laptop-case." *LikeCOOL- Coolest Design and Gadget Magazine*. N.p., n.d. Web. 20 Jan. 2017. <http://www.likecool.com/VAX_Laptop-case--Bag--Style.html>.

Design Idea 1: Rectangular case, Pedal-powered design.

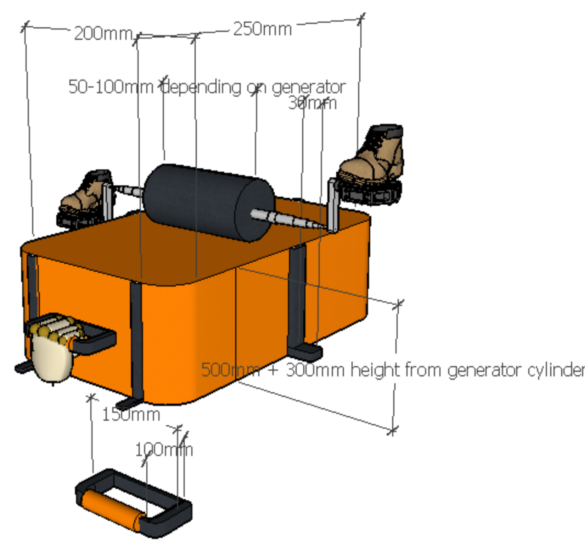
Materials and Manufacture: Outer orange casing is all made of ABS 3D printed plastic to allow for the suitable aesthetics, adapting to the use of new technology, and the casing serves for safety. The black top cylinder serves to encase the generator, which is 3d printed as well. Two bicycle cranks and pedals are placed onto two extendable telescopic sticks, while the pedals have an adjustable rubber straps for ergonomics of the feet at any percentile. 3D printed supports are attached all around the product, 6 in total. Finally the 3D printed handle is covered with orange rubber for cushioning and maximized grip. The circuitry includes a battery pack reaching 20-30V with adapters (USB, 3-pronged at the side) for charging. A 3D casing orange in color and open allows for the fitting of the supports, circuitry, generator, and handle, where they glued in with epoxy resin/ super glue. The cylinder is composed of semi cylinders which cover the generator and have holes at both sides, enabling the sticks to be attached to the generator. The handles and supports are printed, where the handle can rotate around a pivot to fold. A voltage regulator is used to decrease the voltage as needed for phones, and is attached to one of the adapters needed for laptops and phones, around 5V. The adapters are on the side of the orange casing.

Function, Target Market, Aesthetics, and cost:

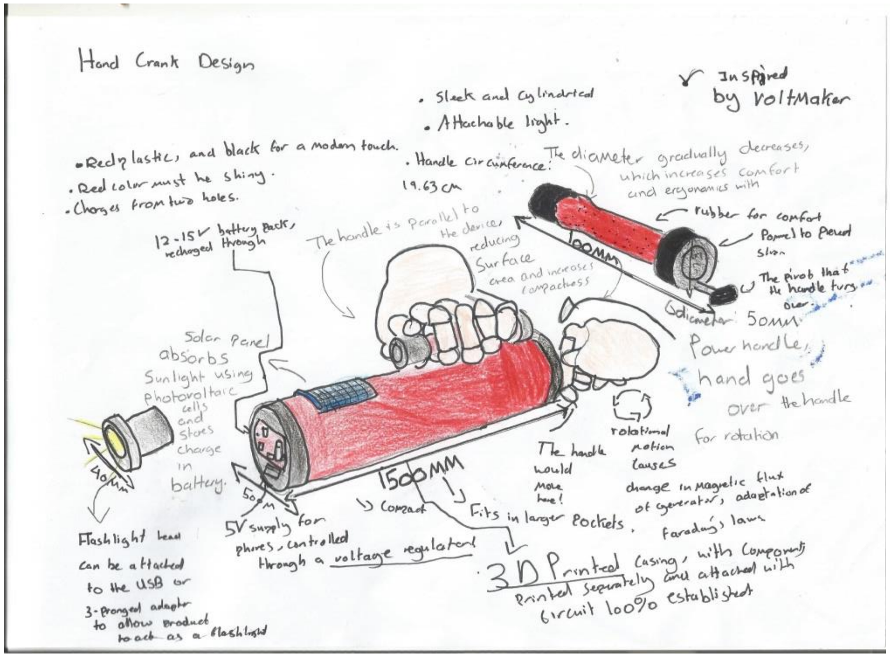
The aesthetics match those of the target market by ensuring that the design is sleek and curved at the edges and uses a modern color pattern such as orange and black as seen here, constructed through detailed fabrication, based on the needs of compactness and ergonomic requirements. This would then suit both males and females, ranging from young adults to adults, yet not entirely as the product is likely bulky and oversized, which does not address the requirement of portability, reducing comfort and needed compactness. Its design is easily adaptable through the form follows function, as the generator housed by the casing is cylindrical, implying the need of a centripetal force generated by the kinetic energy of the legs, which is a sustainable progression of technology, generating 20V and above as larger battery packs can be used to charge larger appliances like phones and laptops through the adapters, as legs are rapid and generate high torque, causing a change in the magnetic flux as the shaft turns. Its bulk and large surface area would need more materials for production, meaning a higher cost at around $50.

Mass: Large size, and heavy circuitry increase mass, possibly making it 0.8Kg or greater than expected. Ergonomics: The product is applicable from the 50^{th} female to the 95^{th} male percentile, as the handle is suitable in diameter, width and length for the largest hand breadth and length. However it can barely fit a standard backpack and can add more weight than needed especially if books or laptops are carried around, causing pressure on the back. Safety and Environment: Is cased in ABS providing safe electrical insulation, stabilizers on side prevent wobble when placed in urban

Compactness: Product is to be placed flat on ground. The dimensions as seen in the sketch are on the higher end of the specifications, not making it compact for storage, and will likely take up most backpack space, making it inconvenient and not very portable as a system. This is a poor adaptation of the needs of the target market, making it uncomfortable, and bulky.



Score: 2/5



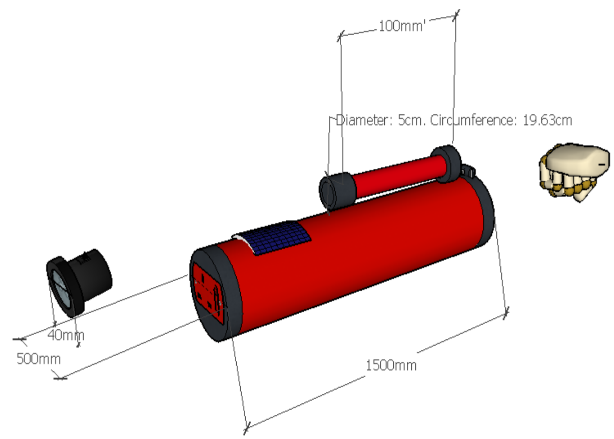
Aesthetics: The cylindrical shape is sleek, compact and matches the needs of the target market of the product being sleek. This is safer and systematically corresponds with the required spinning of the crank. Furthermore, the red and black pattern is modern, especially as the red used here is bright and glossy in nature. The adapter and handles are also colored red to match the pattern. **Target Market**: Through these colors here and sleek design, it well corresponds to the required needs, especially considering the compact design that fit pockets, as well as the active and passive generation of energy, reducing the burden. Portability is also taken into consideration in addressing the needs. **Cost**: The small size and design simplicity would allow the target market to expect a reduced cost, and using less 3D printing can minimize full scale production at around $25.**Mass**: The cost, aesthetics, and target market correspond to the low mass, which is around 0.5-0.8kg, which is realistic for circuitry and components, while easily remaining portable. Note: The mass is estimated and can be inaccurate. **Dimensions**: The dimensions selected are compact to fit in pouches, bags, and tight volumes; however it can be unrealistic as it is difficult to fit all circuitry components into a compact area, which can affect actual mass. The dimensions suit the 50^{th} female to 95^{th} male percentile in dimensions and are as a result highly ergonomic.

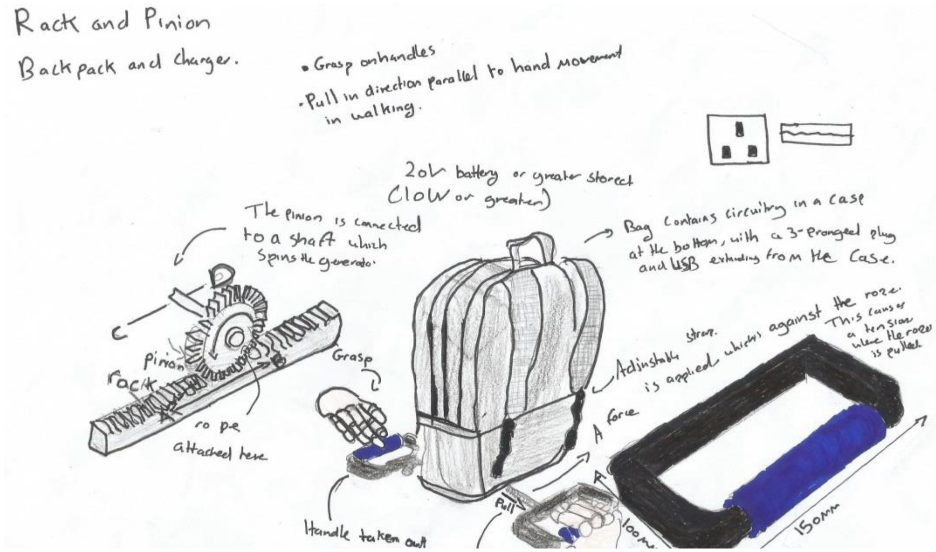
Design Idea 2: Portable Hand Crank Charger

Materials and Manufacture: A red 3D printed tube, 2 black ends, a USB and an adapter for 3-pronged chargers are used for the main body. An all-black cylinder is printed and attached to the joint, in which the connector is on the end opposite the charger holes, and allows the handle to be stowed parallel to the main body to reduce surface are. The handle, which slants for the thumb and other fingers is covered in a red rubber for grip, where the pommel prevents slip. The charger adapters and casings are added after the completion of the circuit and its batteries where they screwed in, and the solar panel is tightly glued on the inside. The flashlight isn't specific, so it can fit through USB, or the adapter.

Ergonomics: Highly ergonomic due to its shape, which allows to slide comfortably into large pouches, and its volume is reduced as the handle is retractable. Furthermore, the hand length, breadth, and circumference were taken into consideration as well as the pommel and rubber slanted grippy handle. Environment and safety: To be used in urban and rural areas, and is stored in pouches and bags, and is safe from electrical shocks unless water enters adapter, and is free from sharp edges, however vigorous cranking can cause hand pain.

Function: The cylindrical shape also applies the form follows function concept, where the centripetal force applied by the hands to the crank turns the shaft, causing an increased change in the magnetic flux over time, generating an induced current and voltage driving charges around the circuit to charge the battery. From here, the battery would be connected to the adapters for charging devices. The solar panel serves to passively charge the device when in sunlight, which is iterative as it uses the existing concept of photovoltaic cells for progression and ergonomics by generating energy passively. **Score: 4/5**





Cost: The system would be pricey, as it requires a casing and two handles specific to be applicable in most backpacks , at around $35, which is between the specification' s minimum and maximum, to make it affordable yet profitable.

Ergonomics: The product would act as a slightly larger backpack with the slightly added weight concentrated at the bottom, however plenty of space would remain for common items when outside houses, making it easy to store without overfilling the backpack. The handles also take into consideration the 95th male percentile in terms of hand breadth, circumference, and length when designing the handle to keep it comfortable for the target market. However, the cord sounds and rack and pinion would be repetitive and noisy

The target market: The target market would be able to charge the product while remaining highly mobile and rely on natural body movement to maximize energy, however if this idea were to be implemented, it would need to work on specific bags large enough, which is no different to purchasing a new bag to use this system.

Cord-pull device charger Backpack (Design Idea 3)

Materials, Manufacture, and function: The product would serve more as a system integrated into backpacks rather than a product itself. It would consist of a 3D printed casing containing a 3D printed rack and pinion gear, which is connected to the generator shaft, generating an induced current linked to a 20 volt battery, storing charge for phones and laptops which can be reduced through a voltage regulator. The rack and pinion can be replaced with a metallic built one, but increase weight tremendously. The handle would be 3D printed and covered with rubber. The pinion would have two cords attached to it, so the circular motion caused by the pulling of the cords when the arms move while walking would cause the pinion to continuously move along the rack, never reaching the end of the rack as it moves in two directions, while generating electricity, through the energy applied by the moving arms when holding onto the handle. The cords directly link to the rack and pinion through holes in the backpack.

"Solar Backpacks." *Voltaic Systems*. N.p., n.d. Web. 15 Jan. 2017.

Dimensions and mass:

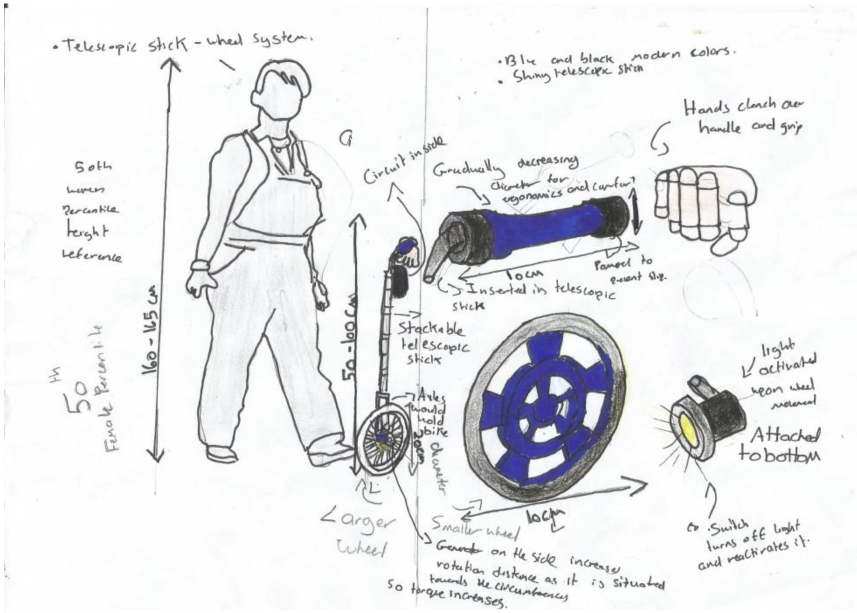
His would uncertain, but the mass of the system without the backpack would be close to the maximum weight specification of 0.8kg or slightly greater caused by the added weight of the rack and pinion. The dimensions of the system include that of a standard backpack which is 30cm wide or greater and 30cm or greater in height.

Aesthetics: Highly depends on bag, blue and black handle allows system to appear modern with curves.

Environment and safety: No dangers, but the circuit can break if the bag is dropped forcefully, and abrasions of cord against skin can burn if done rapidly **<u>Score: 3/5</u>**

heel Stock Photos and Images." *Alamy Stock Photos*. Alamy, n.d. Web. 20 Jan. 2016. <http://www.alamy.com/stock-photo/trundle-wheel.html>.

Telescopic Stick-Wheel System



Cost: The product's simplicity in manufacture and design would allow the price to be low, and its simplicity would provide the target market an expectation that the design would be as cheap as possible, placing its price at $20. Especially that the user's own wheels can be applied

Environment and safety: The product if fully insulated and protects against electric shocks and heat buildups. As the product is retractable and extendable, it can be stored in tighter areas, and would need height more than volume. The wheel used can be from a small bicycle, allowing the product to function in more rugged areas.

Mass: The length of the product and the use of a metal extendable stick and possibly heavy wheel would put the product at the maximum mass of 0.8kg and can slightly surpass the value, however if the device is stripped down, the weight can be reduced when lifting the stick is required.

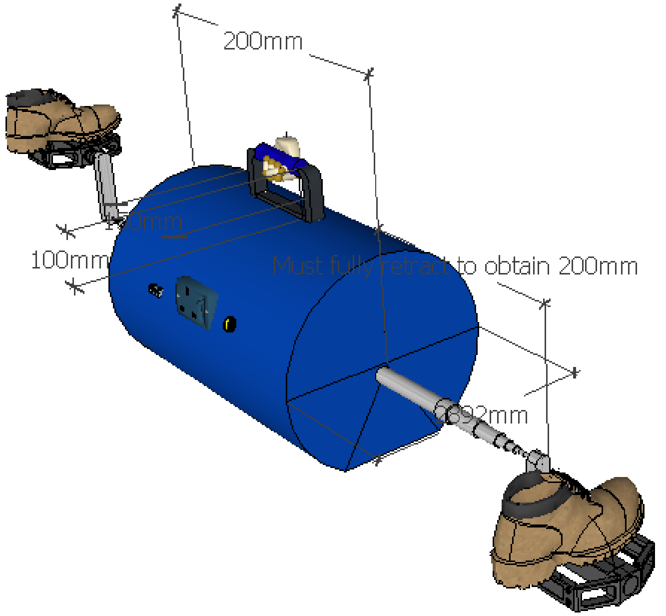
Aesthetics and target market: The sleek curves of the axle and handle, and the use of blue of black modernizes the product, its adjustability allows it to be adaptable by the target market. **Score: 5/5**

Materials, Function, and Manufacture:

The product consists of two axles that are 3D printed and hold a wheel. The side of the wheel contains a generator. Placing the generator at the side, increases torque, which allows for a greater rotation and change in angular velocity, as the wheel as located further from the center, increasing the distance which affects and increases torque. This allows for a change of magnetic flux over time, generating a greater electromotive force out of the kinetic energy of the wheel to drive a greater induced current around the circuit. The induced current would then follow two wires up to a side storage containing the batteries and adapters, similar to the previous ideas containing voltage regulators. The storage would 3D printed black for aesthetics, and the wires made long enough to extend at full height without ripping. The user would hold on to the 3D printed handle comfortably and have grip as rubber and a pommel is used. As the handle is removable from the fully adjustable telescopic stick, the product is highly adaptable, allowing the user to generate electricity passively as the wheel's rotation depends on the movement of the user, without having to forcefully rotate hands in a repeated and tedious pattern.

Ergonomics: The product is fully comfortable and modifiable to a preferred structure through its changeable dimensions, ,and replaceable wheels, which affects the weight, allows for stylish changes in wheels, stability, easy backpack storage, and overall comfort and ease to use, countering the possible bulk of the product. The handle dimensions are built for hand sizes up to the 95th male percentile.

Dimensions: The overall product height is 50cm at minimum and 1 meter long to allow for compactness and ergonomic preferences ranging from the 50th female percentile to the 95th male percentile. The wheel can be adjusted from a diameter of 10cm and replaced with a larger wheel with a diameter of 20cm. The handle is 10cm long with a diameter of 5cm to match hand breadth, length and circumference up to the 95th male percentile.



Function, manufacture, and materials: The legs are placed on the bicycle pedal, which is taken from a bicycle and has an adjustable strap attached to it, from here the pedal is attached to a bicycle crank fully capable of rotation, which is connected to a rotational telescopic stick that can be retracted into the device. The blue cylindrical casing is 3d printed in two halves then glued after the circuit is applied, generating 10Volts or above which charge phones using the adapter. The handle is also 3D printed and foldable, allowing for easy carrying, and is grippy as a pommel and rubber is added like the previous ideas. The kinetic energy placed by the wheels on the pedal, would lead to enough energy to move the induced charges around the circuit, allowing the product to function easily.

Mass, Dimensions, and Ergonomics: The casing s bulky, and having two pedals and telescopic sticks makes it quite bulky above 0.8kg, with a massive volume, that heavily hinders portability, making it too large to fit backpacks, especially with an expected diameter of 15cm and length of 20cm, on top of the extra length added by the pedals. Ergonomically, it would be highly adjustable, as the strap on the pedal can tighten, the stick is extendable, and the handle matches the d95th male percentile in terms of hand anthropometrics.

Environment and safety: The product would be completely unsuitable for backpack storage, and would to large to the point parts can loosen and the circuit can even rattle if there is too much room, leading to parts loosening if the device is not handled delicately, placing a danger on the user. It is also not well suited for rural areas as it is not stable. This would fit in a duffle bag however.

Aesthetics, cost, and target Market: Highly sleek and modernized design, using blue, metallic, and black, but it seems difficult to mass produce due to its large production cost from the material needed, placing it at the higher end between $40-$50. The target market would be skeptical of the design however, as it is larger than what they need, and would be inconvenient.

Not adaptable, would least likely suit the needs of the target market. Score:**1/5**

Cylinder+radioþ - Ãˆ Ã• Ã‹ GoogleÃ¾." *Cylinder+radioþ - Ãˆ Ã• Ã‹ GoogleÃ¾*. N.p., n.d. Web. 21 Jan. 2017. <https://www.google.jo/search?q=cylinder%2Bradio&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjJ_ovY6NjSAhUL3mMKHWOfCgkQ_AUIBigB&biw=1366&bih=613#imgrc=FL4hVccJJCrXyM:>.

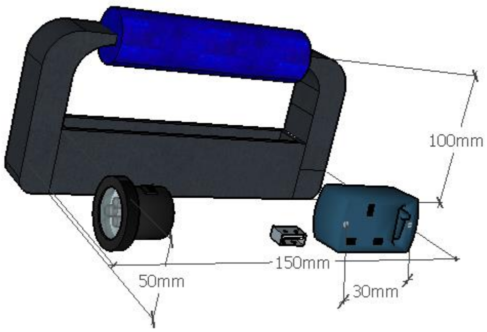
Selecting and Justifying the Chosen Design:

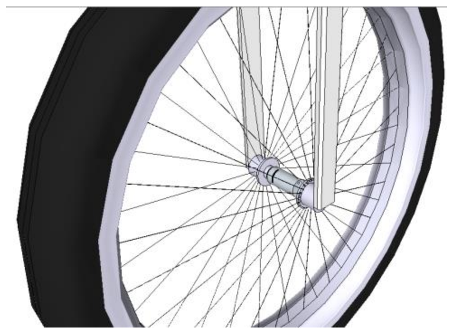
It is imperative to understand which design would best suit the target market's needs, even after placing scores and evaluating each design idea against the criteria to analyze the success of each idea in meeting the needs of the target market. I would be able to easily figure out the recommended design to produce, and even understand how to perfect the design and allow it to match the specification requirements, to allow the product to more effectively meet the needs of the target market. Therefore, I have spoken to an expert, who is an electrical engineer and specializes in designing circuitry for a wide array of products, like drones and interviewed him. I have shown the expert the specifications, and presented all the design ideas in detail. The following questions were then asked:

- Of the five designs, which would you mostly recommend in your opinion and why?
- Which would be the most innovative of the five design idea in allowing the user to charge their technological applications easily?
- Would your best recommended idea follow all Specification points, why or why not?
- What features would you develop to best meet the specification points?

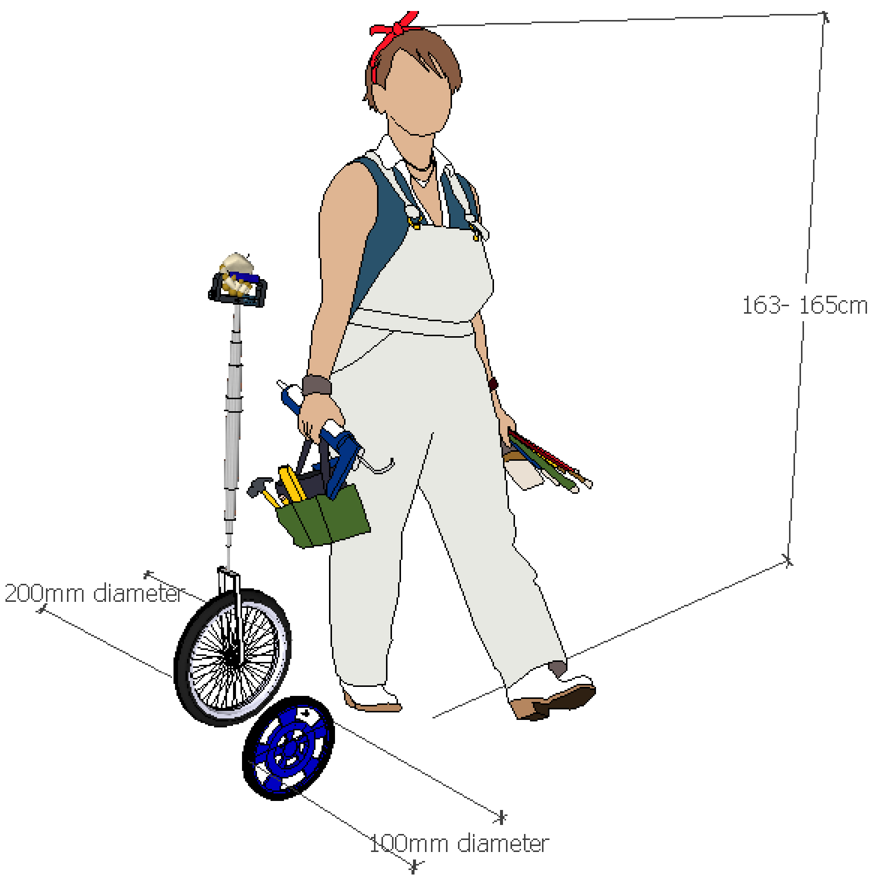
From the interview, I have deduced that the expertise of the engineer and his understanding of the customers needs have lead me to knowing that design idea 4 is the one to follow. In his opinion, the other design ideas would require extensive customer involvement, as " the likelihood of the user stopping to repeatedly cycle or crank" would be seen as boring and time consuming, and probably not too efficient if the user is not vigorously exercising or the generator is not efficient." However, the ability of the wheel to maximize the power output while still remaining wheel is highly appealable according to the expert, and the handle would allow for an easy grip, and an organized circuit, with the adjustable stick progressing electrical gadgets and allowing them to be highly adaptable, which is key for scientific and technical innovation. The hand crank design is too unrealistic to manually prototype and manufacture, as the circuit components need to be sophisticated and compact to fit in a small product while still remaining efficient. The 4th design idea matches all the specification points with its modern look and iterative nature in synthesizing common electrical concepts with mechanical systems like torque. However, it would be easier to build and function if the generator is situated in the center of the wheel, as it allows the axle to hold the generator easily, when the shaft spins. It would require tough work to locate a dynamo that can be mounted on the side of the bike, thus it's easier to allow to spin and set up easily when the generator is centered, despite the loss of torque. However, this can be countered by using a motor with gears, which can reduce the rotational speed of the shaft caused by the wheels, and increase the torque to maximize the power and current of the generator. To further improve on the compactness and aesthetics, it is best of if the flashlight (generator relocated), adapters and circuitry are placed in a larger handle, with the handle design of idea 1,3, and 5, to fit everything together into a more compact space rather than placing a box on the side. A boost converter would needed to amplify the voltage from the generator to increase efficiency, and use a power inverter to convert to 220V AC current required for laptops. From here the design would need to be developed.

Developing the Final Design





The suggested improvements were taken into consideration; the axles have hollow spacing for the wires and hold the generator at the centre of the wheel to ensure the production of an electric current. The handle is 50mm thick, and made 50mm thicker at from the bottom to ensure enough height for the batteries and other circuits, The added thickness ensure that the components will fit. The flashlight is mounted on the side, as the side will face in the same direction as the user, while the adapters are placed on the side.



Final Design

Function: This would function identically to the design idea. The user places their hand on the handle as seen in the design, where their own devices can be charged through an adapter, or a USB. Furthermore, an element drawn from second idea is the flashlight, which is an example of adaptation and progress as it is much safer for the user to activate the device at night. When the user moves, the wheel moves along with them, where the shaft turns and the angular speed is reduced by gears to increase the torque, to maximize the torque and current. From here, a current moves inside the telescopic stick and reaches the handle, in which it is inserted into the stick via a tube integrated onto it. The wire passes though the boost converter to increase the voltage to charge a 10V battery pack or greater, where the battery can power the flashlight, pass through a voltage converter for a USB charger, or move through a power inverter at 220V AC, then to the 3-pronged adapter to charged. The adjustable stick functions as a method to allow for use by the 50^{th} female percentile in terms of height to the 95^{th} male percentile.

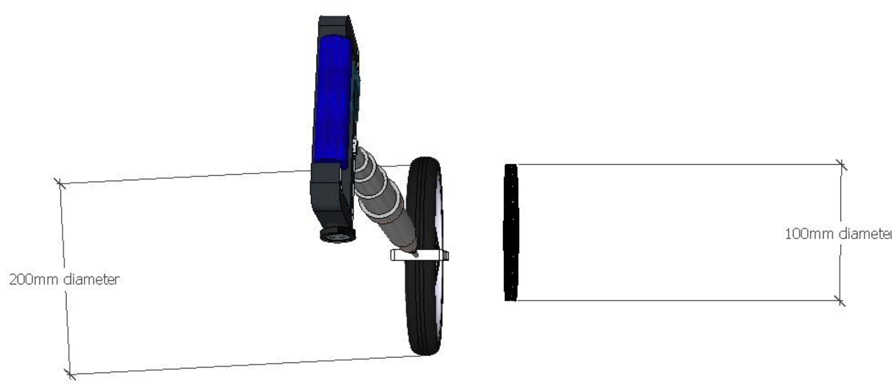
Dimensions: **<u>The telescopic stick extends from 50-100cm, allowing for compactness and comfort without the target market having to lean.</u>** The wheels are fully adjustable and customizable to allow the user to adapt to the product. A larger 200mm diameter wheel can be used, or a smaller 100mm wheel can be used. The handle overall is 50mm thick, 150mm long, and 100mm high to allow the circuitry to fit in, rather than have unwanted surface area added to the design.

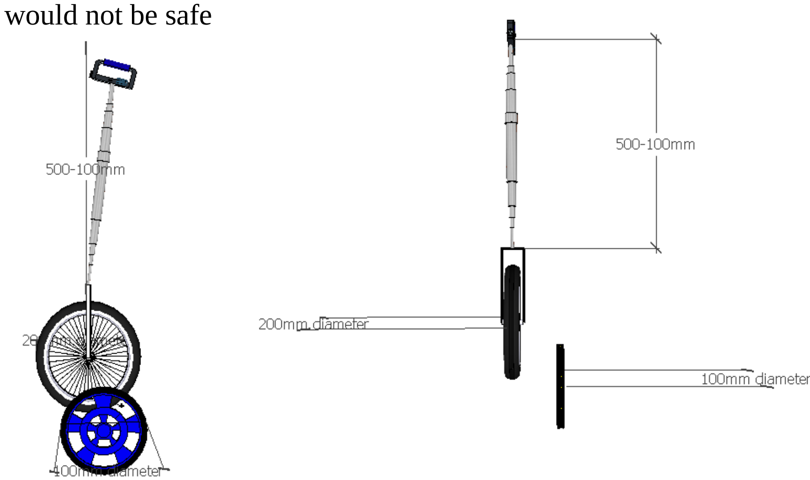
Material and Manufacture: Telescopic stick is pre bought as it is highly complicated to replicate its structure, it also needs to be hollow to allow the wires to move through. The two axles are joined together, where there is a hole with the same diameter as the diameter of the telescopic stick, already printed hollow during 3D printing. The motor and circuit are soldered together using solder wires and a solder iron, where soldered wires are then held together using heat shrinks. Finally the handle is 3D printed hollow, where the circuitry is applied, closed off by using epoxy resin and a strip of 3D printed plastic. Blue rubber is then used to cover the handle top, where it is held. If a pre constructed wheel with a diameter of 10cm is found, then it is painted blue, and then cut to fit the shaft, as the use of household items when applicable is encouraged.

Cost, Aesthetics, and Target Market: The base price is $30, increasing it from its original, as more detail is required into the product fabrication, especially to make it sleek such as the axles, where they are curved rather than straight. The colors are primarily metallic, and matte black and blue, making it subtle yet modern in color pattern. The design is kept simple to make it meet the needs of the target market much more sufficiently, as they require compactness and portability, which is emphasized in its simplicity, where the wheel and handle are connected by an extendable tube.

Mass, Ergonomics, and Safety considerations:

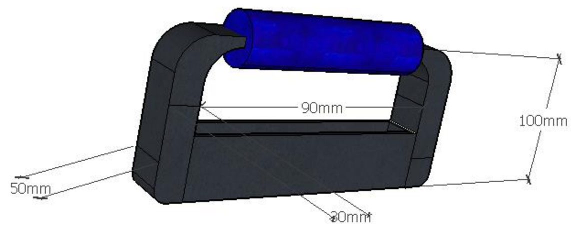
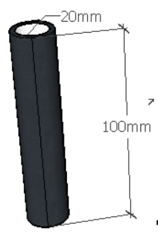
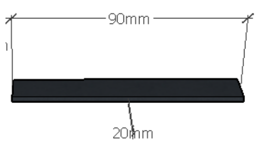
The product would be on the heavier end, especially if larger wheels are used, being at the maximum of the specification at around 0.8Kg, but less than the design idea, as the final design is much more compact. Ergonomically, the target market can carry the product in open sacks and larger backpacks, and have the option to adjust the height as needed and use smaller wheels. It would not be safe when the product is used in areas where there is lots of water or rainfall is in direct contact to the adapters while active, as shocks can occur. The larger wheel is

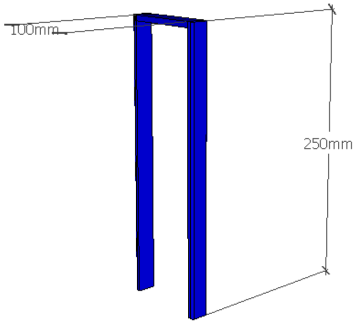
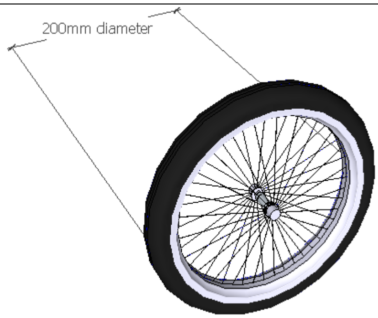
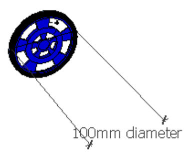




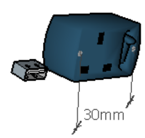
preferred for rural areas, where larger backpacks and camping play a role, while the smaller wheels are best utilized in urban areas.

Parts List:

Part and Property	Dimensions	Quantity
	The handle is 100mm high x 150mm long x 50mm thick. Rubber handle, 3d printed ABS.	X1.
 The tube that connects the handle to the telescopic stick (hollow)	Diameter is 20mm, total height is 100mm 3D printed	X1.
 Handle cover (placed after circuitry completed and tightened with adhesive.	90mm long, 20mm thick, 50mm wide. 3D printed.	X1
	Telescopic pole: 500-100mm long Aluminium.	X1

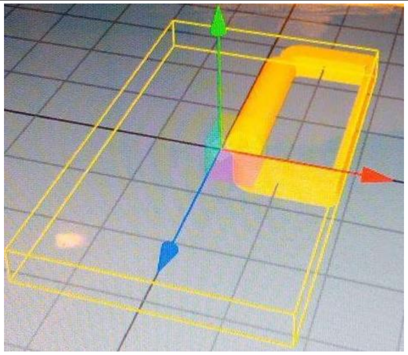
	250mm high, 100mm wide. 3D printed Wheel holder containing axles.	X1
	200mm diameter wheel with tire, bought or found as household component.	X1
	100mm diameter wheel, 3D printed.	X1.

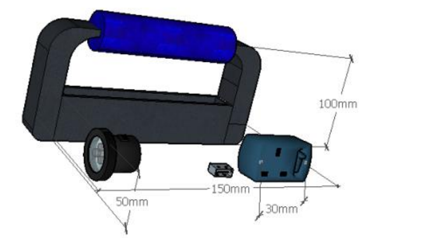
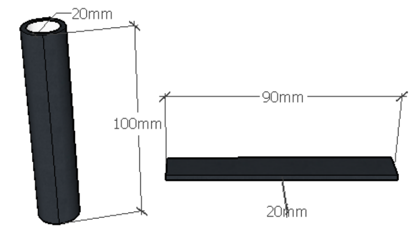
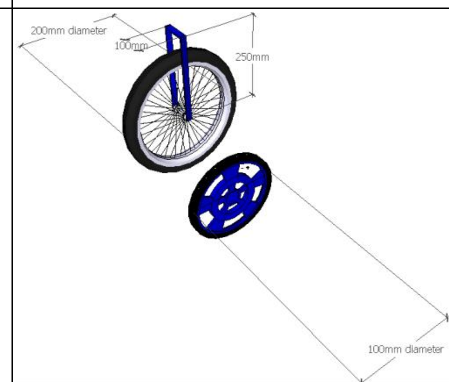
Electrical components: 3-pronged adapter, USB, Falshlight, motor, wires, boost convert, 10V battery or greater, wires, power inverter, Voltage regulator



Criterion C: Creating the solution

Step	Quality Assurance and Quality Control	Materials	Tools Needed	Time Needed	Images/ Sketches
Ensure All materials are present and functional.	Ensure the wheels roll properly, the batteries are functional (hot wire and measure current using multimeter briefly). Ensure chargers fit adapters easily without issue. Replace if the adapters are faulty.	200mm and 10mm diameter Wheels (if cannot be printed), generator, wires, boost converter, battery pack, tape, solder, solder iron, tape, and adapters. The telescopic pole must not take too long, as it is expensive and wasteful of plastic Ensure Access to a 3D printer.	A soldering iron and solder are needed for the circuitry, as well as a heat shrink plastic, a lighter for heat, tape for wires, and a wire clipper.	10 minutes.	
Use the soldering iron to solder the batteries into each other, to maximize the voltage up to a minimum of 10v. The number of batteries needed to be soldered together relies on the individual voltage of that battery (must be done in series).	QA: Ensure wire stripping before soldering must not remove any copper. QC: test the batteries using a multimeter, and test voltage and current in a short circuit to see if the batteries remain functional. Close the circuit before testing	Solder, multiple lithium batteries to reach a min of 10V, heat shrink.	Lighter, and soldering iron, multimeter. Always place soldering iron in the stand when not needed (safety). Tweezers to close circuit, wire stripper or wires	20 minutes.	
Solder the battery pack onto the power inverter, placing the wire terminals at the highest voltage settings. Then proceed to solder two thick wires (increase current and reduce resistance) from the power inverter to the 3-pronged adapter, keep in mind the heat of the	The soldering iron must not come into contact of plastic, but only the metal itself to allow for conduction. Use the multimeter to test for a current (e.g wires placed at 220V must give a reading of the same or greater as no appliances are added). Continuously use Strip wires carefully to not split copper wires. QC: If the there is no multimeter (ammeter works) reading, then the circuit is not closed or there	Power inverter, solder, wires	Multimeter, soldering iron, pliers/ wire stripper	15 minutes.	

soldering iron as a source of danger.	is a defect, that needs further inspection or even a replacement.				
From the inverter once again, solder another wire and attach and solder a voltage converter and insert into a USB. Then solder a switch onto a wire extending from the battery	Consistently check the status of the circuit using the multimeter, closing it off using tweezers as with all steps.	USB, voltage converter, inverter, solder	Soldering iron, multimeter, wire and wire stripper/ pliers.	5 min	
On a different location, strip two wires and attach them to the terminals of the generator, regardless of wire color needed, (reversing the generator spin reverses current). Ensure the wires are tightly soldered and covered using a heat shrink or duct tape. Then solder the boost circuit onto one of the wires that lead to the batteries. (amplifies voltage from generator)	Check that the generator spins, and test the circuit using the multimeter and tweezers to close the circuit off.	Generator, wires, solder wires, and partially completed.	Soldering iron, multimeter, lighter for heat shrink, and wire stripper/ pliers	10 min	
Convert the required design components to an stl. File and place the files on a slicer or fixer program to adjust the dimensions to the right scale and adjust the quality to the highest. From here proceed to 3D print the wheel, wheel holder (needed for axles), and handle.	As this is as prototype, double check that the dimensions what is required, and that the print quality is set to prototype to reduce needed time. The wheel holder must have two holes with the same diameter as the ends of the generator (the generator then acts as the axle with its shafts to hold the wheel and attach it to the wheel holder. The wheel holder must be printed internally hollow to allow	PC with design software (Sketchup, with fixer program such Makeprintable)		7 hours (or more depending on 3D printer).	

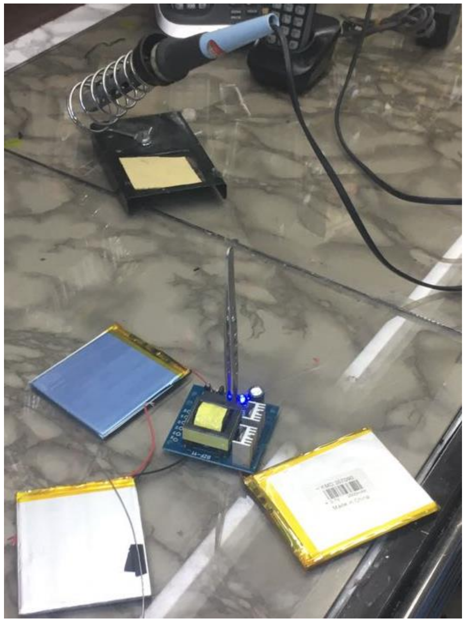
	wires to move up to the telescopic stick.				
Attach the circuit to the inner part of the handle and use epoxy resin or tape to secure the circuit onto the handle. Then attach the adapters, USB, and flashlight to the empty spaces, and use a glue gun, or epoxy resin to fasten the adapters.	Slightly wobble the components to ensure, if the parts move too much, they require more adhesive.	Circuit, handle, flashlight, USB adapter, and 3-pronged adapter.	Epoxy resin, or other adhesives	20 minutes.	
Use the rectangular 3D printed strip to cover the circuit and tighten it with epoxy resin. Then attach the tube that connects the handle to the telescopic stick to the handle itself. Glue rubber around the handle.	Place a coat of adhesive (epoxy) that ensures the handle cover is tight, ensure that the tube is not wobbly and tightened by using adhesive. From here, the part of the handle where the hand is placed is ensured that is entirely covered with rubber. The handle should not be glued, to allow it to be removed when needed (maintenance or part replacement) but should tightly fit.	Tube , and lid.	Epoxy resin.	5 minutes	
Attach the generator to the wheel and then the shafts/ axles to the wheel holder at the holes, extending the wires up both sides the wheel holder and up the telescopic stick (internal wiring). Repeat with the other wheel.	**The step relies on specific 3D printing dimensions, which is affected by the exact motor and wheels required . The diameter of the wheel holder holes are determined by the generator the hole for the telescopic stick is the same diameter as the telescopic stick. If the telescopic stick, and shafts do not wobble, then the parts perfectly fit, if not tape (temporary solution) or glue is needed (however this prevents the product**	Soldered wires, wheel holder, tape if hole is too large.		10 minutes.	

	being disassembled when needed (<u>major issue</u>). QC: Ensure the generator fits the other wheel (smaller or larger), this detects whether the product has been affected in terms of adjustability. If no wheels fit, then the motor needs to replaced, or a new set of wheels to be found.			

As a final quality control check, the product is to be activated with the switch turned on, and the product is taken for a test run to ensure the batteries can be recharged and that the batteries can charge devices.

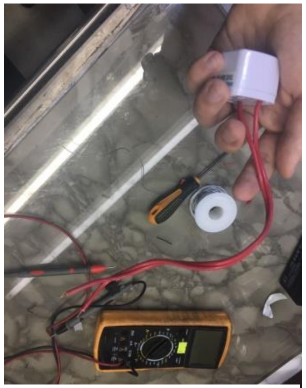
Note: A soldering iron is a tool (see image) used to join wires together by placing a small thread of metal known as solder, which melts at 183°C by the tool. It's extremely hot and can cause **severe burns on fingers if not used properly**. By soldering, an additional wire or circuit component is added, enabling charges (current) to move through the metal (electrical conductor). **This must not be done when the circuit is activated**. The circuit should not be touched at all when it is active, as the power inverter or other components can cause a harmful shock. (Environment and safety). The soldering iron allows for existing electrical applications to be adaptable and adjustable for specific purposes and allow circuit customization. Finally it should be placed in its designated stand and not flat on the surface (surface can be damage or potentially burn).

Evidence of making: Demonstrating Technical skills:



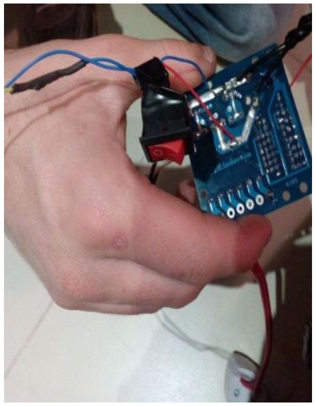
Soldering batteries and power inverter: involved the gathering of the required materials, which was considered very time consuming, making me rely on communication and research skills to source the required components. From here, I have synthesized my knowledge of current electricity, to perfectly solder the batteries to each other. I have adapted my understanding of physics to create a solution to a major issue. **As needed in the production plan, the 3.7 volt lithium batteries had to be soldered, as finding a battery capable of 10V that is lightweight was incredibly tough, as most batteries were lead acid batteries and were incredibly bulky, which opposes the portable and lightweight nature described by the specifications.** Maximizing the voltage needed an understanding of currents in series, where the total voltage of the batteries is combined, allowing for a more effective battery. I have also emphasized on quality control when dealing with this step, as the probability for a faulty circuit is quite high. Therefore, using tweezers and a multimeter allows for the circuit to be closed. With the batteries soldered from the 0-5 pin, this allows for the multimeter to display a 220 volt reading, indicating success. Environmental considerations and safety were taken into consideration by working in a well lit room, and using a soldering iron stand to prevent burning the workshop table, and not touching the tweezers or inverter when activated. This has taken 40 minutes, 5 minutes longer than the second and third step combined. Tools: Heat shrink and lighter (caution needed with flame) to close soldered wire, and soldering iron and solder wires were crucial for the step, and pliers were needed to strip the wire.

Step 2: **Finalizing the main circuit components. Circuitry skills**

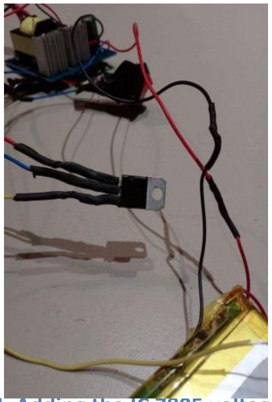


1. Attaching 3-pronged adapter to circuit

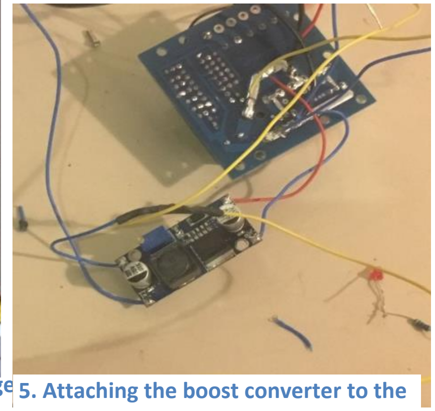
2. Connecting a solar panel to the batteries through wires



3. Attaching 2 switches (will be explained).



4. Adding the IC 7805 voltage converter to the circuit and connecting it to a USB adapter.



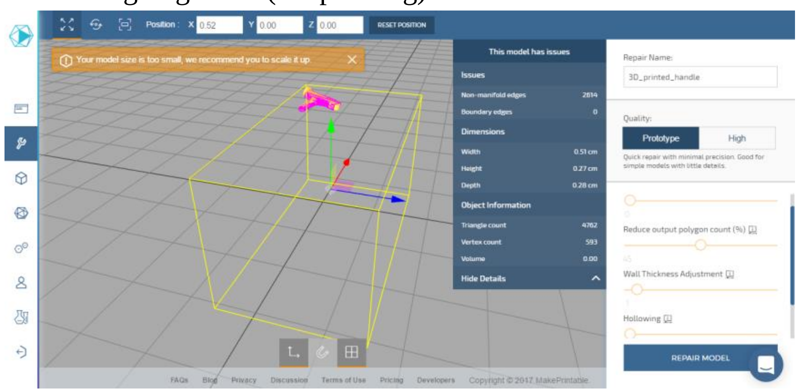
5. Attaching the boost converter to the wire that leads to the motor. LED used for QA

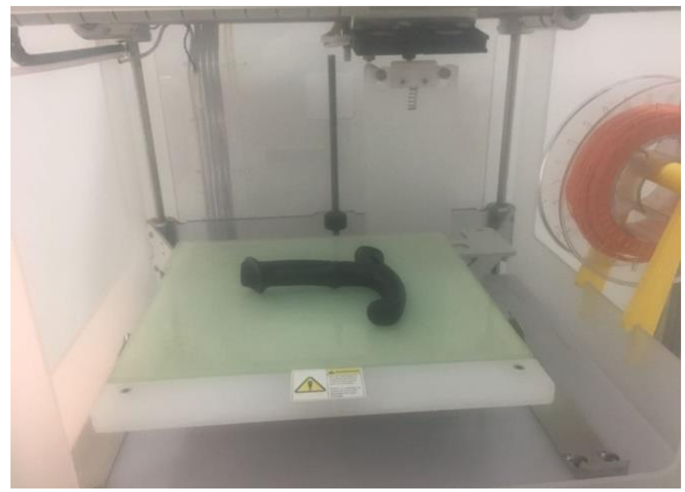
The total time taken to complete this step is a total of 40 minutes. The completion of the circuit has heavily relied on circuitry and electronics skills. As a simple quality assurance, a small red LED is attached to the circuit, if the LED lights up, then the circuit is closed and fully functional. Using this as a quality assurance method reduces the time needed to set up the mutimeter again. However as a highly accurate quality control method, the multimeter measured the voltage when the solar panel, boost converter, and adapters were added, in order to detect any possible failures in the charges being driven around the circuit. **Precision skills** were needed to ensure the circuit was perfectly installed, and decision making skills were involved, as I have decided that wires medium in length in relation to short wires would be the best choice, as it provides a balance in sustaining tension when pulled, and being compact enough and keep the circuit organized. Furthermore, I have combined my knowledge of circuitry and renewable energy sources to install a solar panel containing photovoltaic cells to recharge the batteries under direct exposure to sunlight, hence upgrading the overall idea. The time taken is 10 minutes above the original as the idea to use a solar panel was not planned, and I decided the generator would be installed last to determine the appropriate wire length and setup for a stable circuit. Tools: wires, soldering iron and solder, LED and multimeter for QA and QC respectively, pliers for stripping wires. Thicker wires were used for the adapter as they reduce resistance and increase current, where $Resistance = \frac{\rho L}{A}$ Where ρ is the wire resistivity, length is L, and A is the cross sectional area, which reduces resistance.

Step 3: Manufacturing Problem solving and Painting skills.

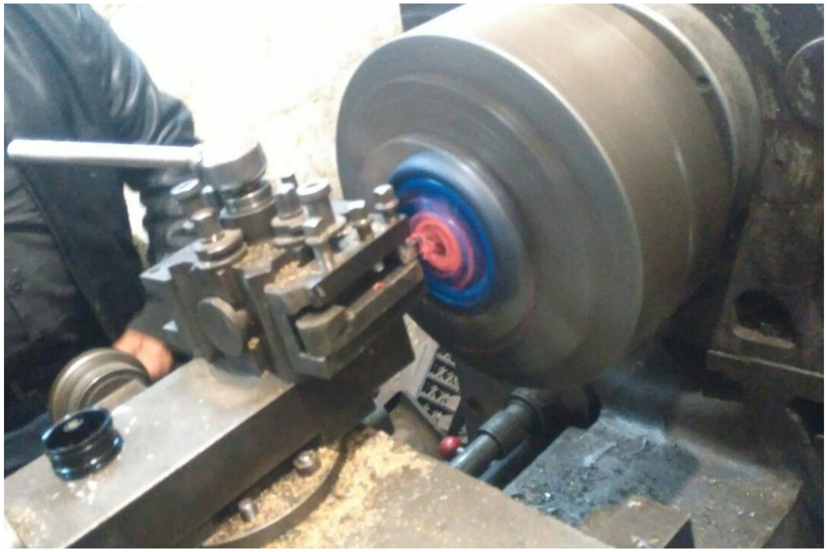
It has come to my realization that 3D printing wheels and a wheel holder would be too expensive at a printing center, considering the fact that the product is a prototype, and that the specifications stated that the use of household materials is encouraged as it would be economically less burdening, more accessible and a lot less time consuming compared to a 3D printer which takes much more time, ranging from a few days up to a week, bringing useful time for production to a halt. Furthermore, the generator sourced, generates 24V, and 500 mA (current) resulting in 12W when the voltage and current are multiplied by each other. This motor would be ideal, however does create an issue. The probability of an issue with the 3D printed wheels is likely high (axle's not fitting wheel holder, motor not fitting wheel). Therefore, I have begun to use premade wheels, however the motor does not fit as some wheels have holes too small or holes too large to be attached properly, and the axles can be stabilized without the wheel holder. However, the motor came with a pair of wheels that fit the axles. This realization has altered the production, where I have gotten two pairs of these smaller wheels of diameter 5cm (excluding tires). The first pair would be used as an alternative (smaller wheel choice) and the other would be fitted on 2 larger wheels of diameter 12.5cm taken from a baby stroller. This reduces production time and cost and allows for a simpler design excluding the wheel holder, where two wheels are directly attached to the motor rather than one (possible weight increase). I have taken 1 hour in this step to paint the smaller pair of wheels to be fitted on the larger wheels black using glossy spray paint, while using an extractor to absorb the smell and the particles that can cause breathing issues (environmental consideration). Much of the time was taken to wait for the black wheels to dry. Finally the red color should be replaced with blue to follow the design pattern, where the black outer part was covered with masking tape, and the wheels were hung with wires acting as hooks and painted blue and left to dry. QC: To check for lumps on the black wheels, the tires were attached. If they do not fit, then there is a lump of paint preventing this.

Step 4: Software and designing skills (3D pointing)



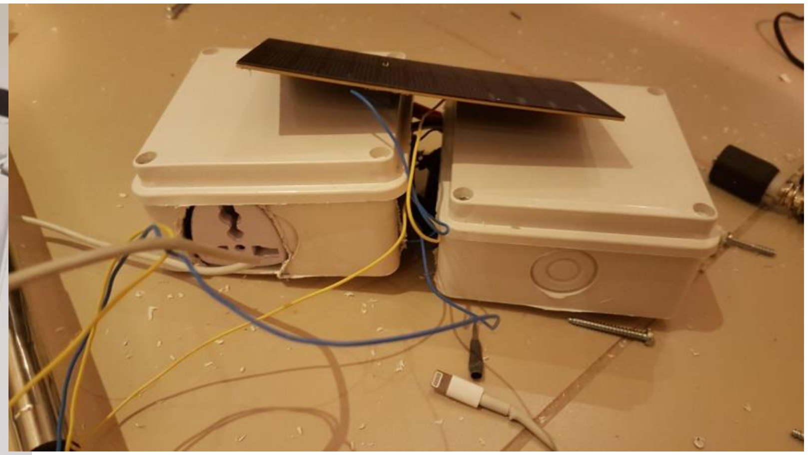


The total time taken to complete this step is 5 hours, where 1 hour is spent redesigning a handle and placing it in a fixer (slicer program), and another 4 hours were needed to print. Initially, a 3D printing centre was consulted for printing the original handle, however they told me that the plastic thickness would be too little, and that the material (ABS) from the 3D printer would easily bend and break under enough weight and pressure where the handle is held. Thus I have redesigned a handle to fit the telescopic stick which has a diameter of 2cm, including a pommel for the thumb, and a curve to prevent slip, and would take into consideration the hand breadth and circumference (10cm) of the 95th male percentile. This would however not fit the required circuit. The fixer program acts as the quality assurance needed for the right dimensions (12 cm wide, 13 cm high, less when inserted into telescopic stick). Environmental consideration: Do not stick too close to the 3D printer, there is a possibility of the ABS particles being released and inhaled (toxic).

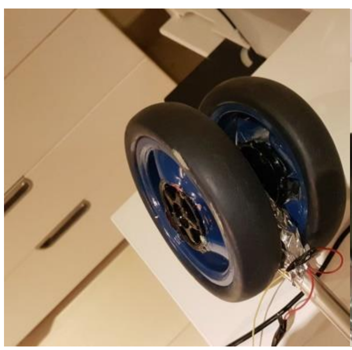
 

Step 5: Machinery cutting skills

This step began by replacing the circuit location to the side of the telescopic stick, and using two small electric main switch boxes. These are incredibly lightweight, easy to cut, curved in shape and compact overall. The two small boxes are low in width, which is why two are used rather than one, and can be covered with screws (a large one has a massive width). The two adjacent sides are cut with dimensions 8 cm wide x 4 cm high (2 cm of width thickness kept otherwise base would be broken off, while (4cm of height as lid covers top). The saw is dangerous, so I had to work in a well lit room and keep fingers away, and tightly grasp the saw. Furthermore, plastic particles would be spread in all directions, goggles were worn to avoid eye irritation (crucial when using saw).Then the smaller black wheels were placed on the center and a marker was used to mark the measurements on the larger blue wheels. Then a lathe was used to out the plastic (red plastic was the unpainted plastic). Finally the black wheels were fitted onto the center of the larger wheels and super glued. The process has taken 20 minutes. QC: Ensuring the lids fit properly and the wheels roll



Step 6: A drill was used to cut 4 holes on both boxes, for the USB, switch, circuit lights (to know if it is functional), then the holes were filed to keep them consistent. Then the circuit is placed where the two sides have been cut out, the wires have been tucked except for two wires. A drill was used to cut a line for the 3- pronged adapter then filed, where the adapter is kept still and glued with a glue gun to keep its position permanent. The switch and USB adapter were then attached to openings by using a glue gun on the inside. A battery charger has beem soldered onto the battery openings to allow for passive charging when needed (increase product adaptation) Then super glue has been used on the open sides to close them off. Then a screw driver is used to seal the lids. The solar panel from the lower bits (no PV cells) were taped to the surface. A phone charger was placed in the adapter to ensure the circuit is active as quality control. The total time of this step was 20 minutes. Safety: I had to be cautious when using the super glue as it can stick to skin and solidify it, and is tough to remove. It can only be peeled when its structure has weakened and disintegrate after a few days.

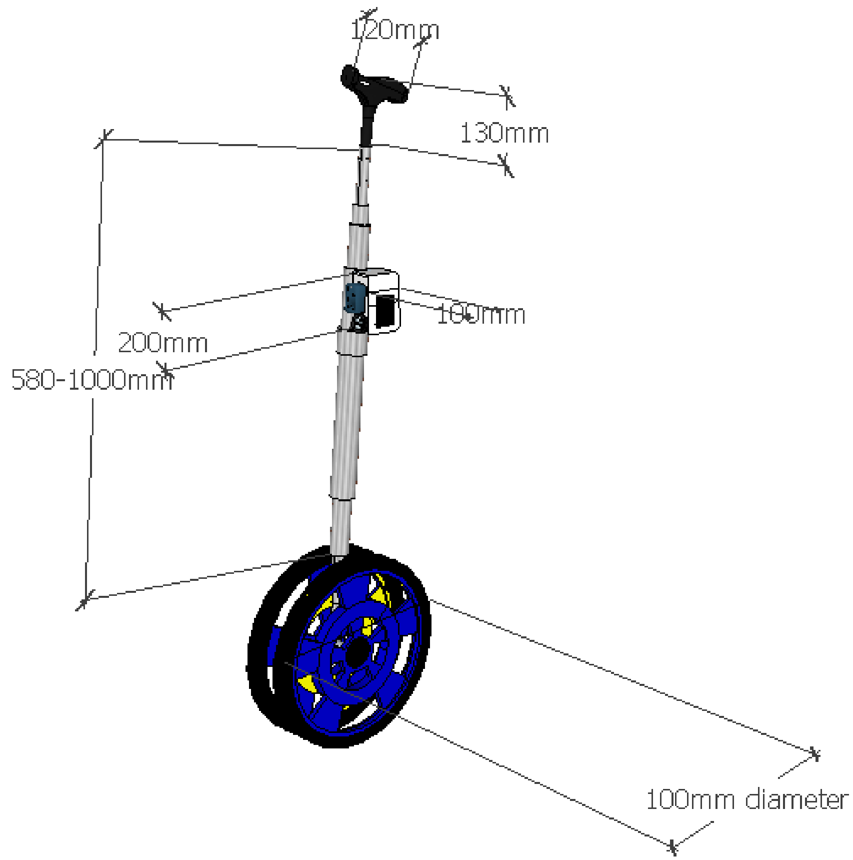


Step 7: Repairing skills

The telescopic stick wasn't hollow when it was dismantled, & wasn't opening and closing properly. Upon further inspection, I have adjusted the spring's position and tightened it. The Flashlight has been added to the side of circuit box, and tape and zipties were used to used to attach the board to the stick. The motor was then taped to the stick and wheels were attached. However, the wire was cut when the stick was at max height, so it had to be longer by soldering, and kept in a straight line (not coil) by consistently heat shrinking. This has taken 10 minutes in total. Fingers should be kept off the lighter when heat shrinking.

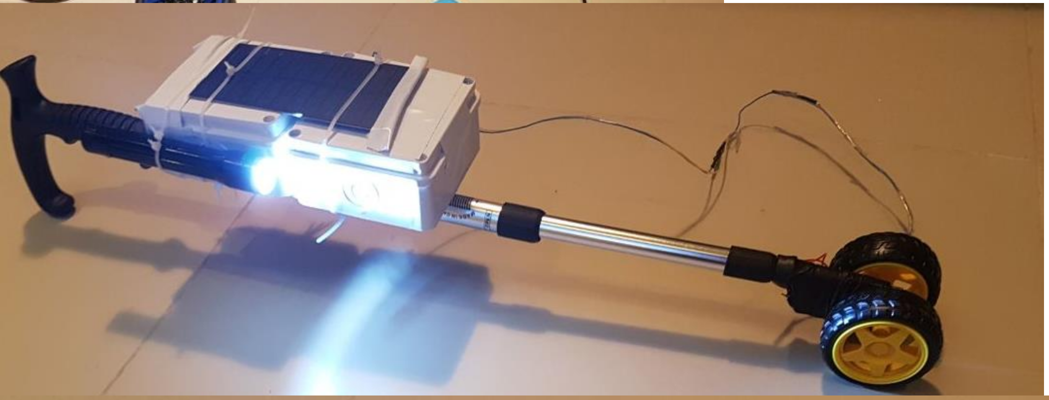
Justified Changes & modifications made to the production plan and design

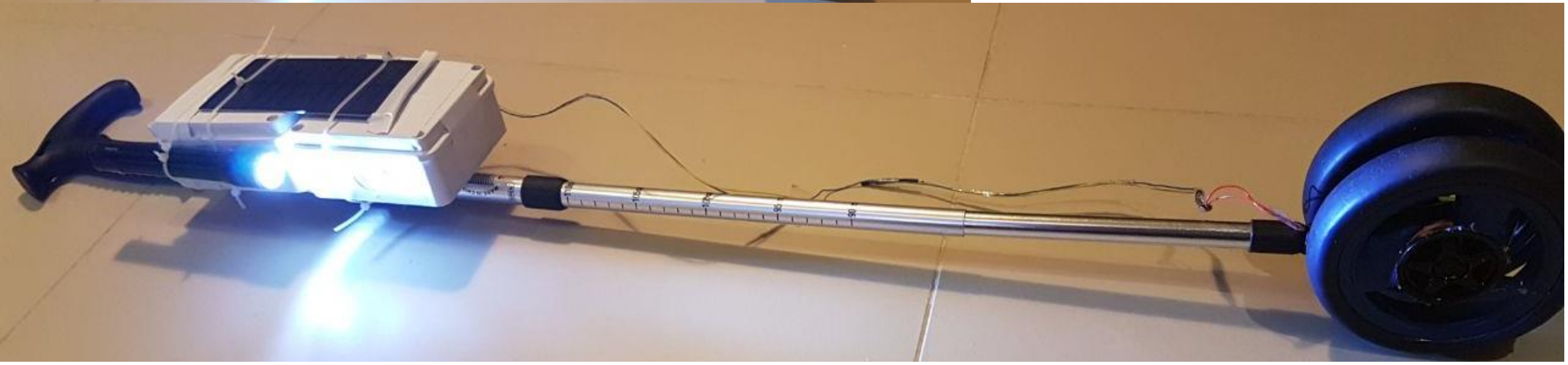
- The original production time in the plan in total was 8 hours and 30 minutes, the actual manufacturing time was 9.8 hours, meaning it was 80 minutes longer (1 hours and 20 minutes).
- The wheels, and wheel holder was not printed
- A circuit box (main switch boxes) was made because a different handle had to printed.
- The larger wheel is 12.5cm as opposed to the expected 10 cm.
- The circuitry is side mounted and the flashlight is external from the circuit.
- Two pairs of wheels in total.
- Saw and lathe were needed for cutting the main switch boxes and wheels.
- Generator needed to be placed in the last step.
- The telescopic stick is 58cm to 100cm, rather than 50cm to 100cm.
- The addition of a solar panel to the product
- Painting the wheels with spray paint (small are black, large are blue.)
- The addition of a battery charger.



Presenting the solution:

The device allows for the charging of a wide variety of devices such as phones and laptops to be charged. The battery pack can also be charged. The product has a USB and 3-pronged adapter. The wheels (diameter of 5cm) can replaced with larger ones of diameter 12.5cm. The minimum height of the telescopic stick is 58cm, while the maximum is 1 meter; its diameter is 2cm, and circuit box is 20cm long and 10cm wide, while the handle is 13cm high and 12cm long with a diameter of 10cm. The flashlight is 14cm long**.**





Criterion D: Evaluating

In order to measure the success of the product with the Target Market, the product is to be tested in three methods: An expert Appraisal, a user trial, and performance testing.

Expert Appraisal

I have shown an expert, who is an electrical engineer at Siemens (electronics company) with experience in quality control, my specifications and demonstrated the product to her. I have asked her the following question: What are the best and worst aspects of the product in terms of the specifications, which include function, materials and manufacture, mass and dimensions, ergonomics, safety and environment, cost, and Aesthetics?

Response:

- In terms of function, the product and components can charge most modern products, especially with the power inverter producing 220V, which can charge most known laptops as they convert from AC to DC. Furthermore, the fact that phones can charge at 5V from the battery, and the presence of the solar panel and battery charger makes it so that the user doesn't need to keep charging by moving, and allows the user to be stationary. I realized that the USB adapter is placed so that USB chargers are hard to place and remove. The product also seems to be very inconsistent and is unreliable in charging. It does not charge at a stable rate, and is lackluster because of it. However, the off-grid system where a person uses his own energy to allow wheels to spin for a change in a magnetic flux, allows for a stable induced current especially through the use of the boost converter. The larger wheels are too heavy for the motor, which is unreliable as they keep falling off. In theory, the product is excellent, yet it requires better execution. High output overall (24 volt motor converted generator, motor repurposed to convert kinetic energy to electric energy
- In terms of materials and manufacture, the materials like the 3D printed handle, wheels, and circuit components are excellent, especially the solar panel placement. However, the manufacture must be improved so that the extendable stick does not fall off easily, it needs to be stable and sturdy. Don't use zip ties and tape, for they affect aesthetics. I did not like the switch boxes used on the side, they take up too much space and are also unstable, meaning it can fall. More professional 3D printing or CNC can perfect fabrication, yet because it's a prototype, the use of household materials can be justified. The product quality is severely affected by the fact that the wires are exposed, it reduces the aesthetics and is dangerous.
- The product feels lightweight overall, yet 0.8kg for a max is unrealistic, it feels easy to carry overall. However, the weight distribution rather than the mass is an issue, it should be even, but I feel a large amount of inertia at the top while moving the product from below is responsive, making it harder to walk with. It needs consistency.
- It does not take much space, except for the box, yet its height makes it so it won't be carried around in a closed bag, but potentially sticks out of the bag slightly.
- Ergonomically the handle, is large and fits comfortably in my hand, it has plenty of room, and it fit the more masculine hands comfortably. Yet the weight distribution, and massive height makes it awkward to carry around with it and walk with it. However, the wheels still feel small, and the product forces someone to hunch over to walk, which is uncomfortable.
- The product when placed lower at the middle is at a risk of being in contact of water, causing shocks. It appears to have a high resistance, which causes a heat buildup. The wire exposed wire can easily be cut in the surroundings, and is risky. The larger wheel keeps falling, which wastes time.
- Aesthetically, it's too rugged and boxy, the circuit can be placed in a cylinder around the telescopic scope or integrated in the handle as you demonstrated in the design, the wires must be

internal and not outside, and minimize tape and zip locks. It would be better off there was color consistency (like only black and blue), so the telescopic stick needs to be black.

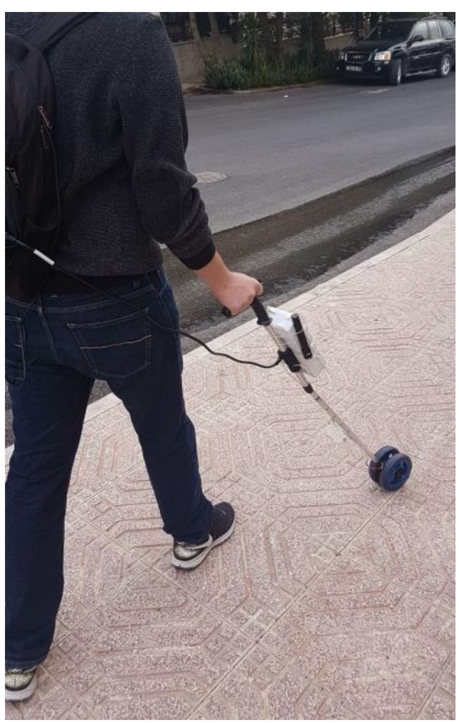
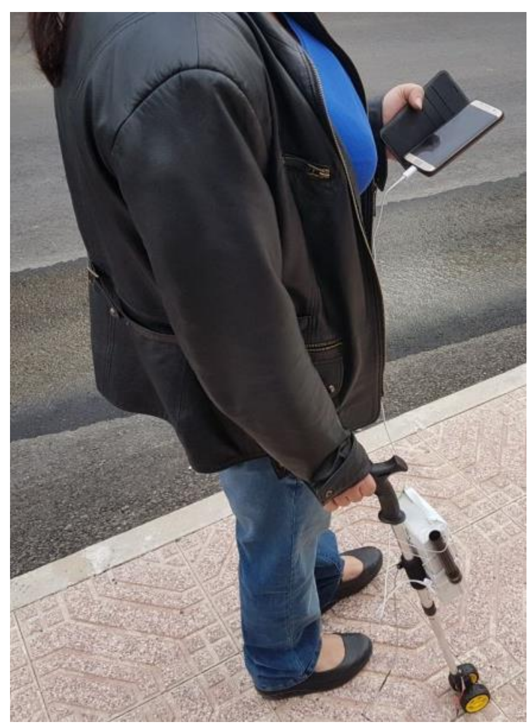
- Overall the idea is excellent, yet it requires professional fabrication using 3D printing, needs more larger and more stable wheels, a stable circuit, only internal wires, and a counter to the heat buildup, a stable telescopic stick (not wobbly). Consistent coloring, even weight distribution, and a more compact design. A printed **circuit board** (**PCB**), would solve the circuit issue. With minimal 3D printing and improvements, I believe it should be sold for $25, but with more 3D printing, it should be at $40. Average execution overall, I rate this a 5/10.

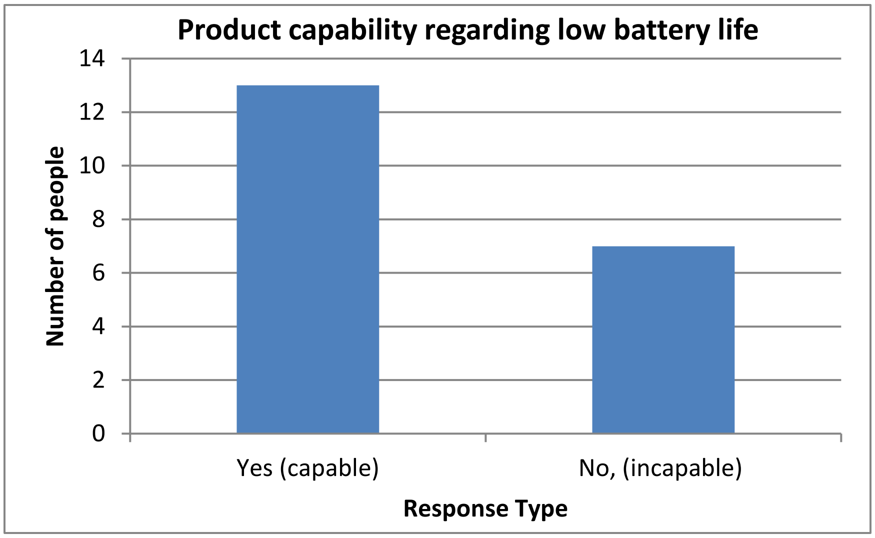
User trial: (Quantitative and qualitative)

I have taken the product to 10 men and 10 women (ranging from young adults to adults), and had them take the product for a 5 minute test run with their phone, or a laptop to carry around for 5 minutes while charging. The data is diversified between quantitative and qualitative data

1. Considering the fact that the product is a prototype, what do you think of the product overall in terms of general function, aesthetics, and comfort? What would you rate it out of 10?
2. Do you find the product capable of countering the issue of low battery life, especially when on the move? Why or why not?
3. In which aspect would you improve the device? How?
4. If the product implements all your needed improvements, what would be the best price range, $10-20, $20-30, $30-40, $40-50, or above?

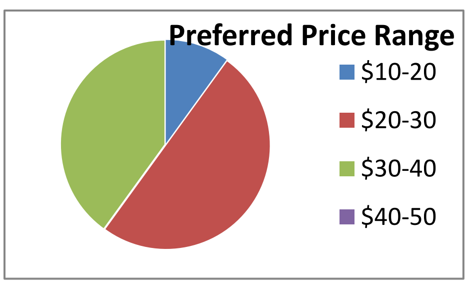
1. 12 people have found the product to be average in terms of the three aspects, where a sample of those 12 out of 20 were taken, 7 rated the product 6/10, while the other 5 from the sample rated it a 5/10. They saw the product more successful in theory rather than build, whereas 8/20 people see the product lackluster in idea and build overall, where the ratings were under 5/10, claiming it to be ineffective, where lighter products can charge more effectively, as it is difficult to keep the product on standby.



It appears that the majority of people, 13 out of 20, specifically see that the product is capable in acting as a solution in countering low battery life situations, meaning that most of these 10 men and 10 women see the product capable in addressing the needs of the target market, leaving a 6 person gap between those who have said yes and those who have said yes, share the idea that the solar panel, wheel, and battery take advantage of the surrounding environment, and maximize the power production efficiency as there is more than one way to charge. The 7 people who have disagreed, felt that they would be too bounded by the product, and would have to be forced to reduce their mobility to charge their device, forcing them to carry more than what is required.

3. All 20 people recommended improving the product in all aspects. People, felt that the product felt strange to walk with, as it is wobbly, and the wheel was so small it the user into hunching over slightly, restricting their movement speed more than they should. All saw that the circuit placement aesthetically needs improvement, whether tightening it. All agreed that the wires should not be outside, but rather inside. The telescopic stick also needs to be rigid if a user is going to be moving quickly. 15 users recommended highly consistent charging, and emphasized improving the rate of charge as much as possible. Aesthetically, people preferred a consistency with plastic matte colors, and it would entirely fit in a bag and be closed rather than stick out, and extending the max height as much as possible helps, as it allows for more placements when the product is tilted and the user is moving. Ergonomically, the handle is seen as comfortable. 18/20 enjoyed the use of blue.



10 out of 20 people have chosen a balanced price range of $20-30 dollars, while only 2 have chosen the minimum price range of $10-20, and 8 have chosen the moderately high price range of $30-40. The moderate price range is justified by the fact that those with a high number of electrical gadgets running into the issue of low price range, would be able to spend for a slightly higher price, yet would not want to experience a higher economic burden, explaining why no one chose the highest price. Furthermore, the moderate prices were mostly chosen as a result of acknowledgement that upgrading the product and refining it would require more money to upgrade its potency and effectiveness, thus increasing quality.

<u>Performance testing:</u> Dimensions were recorded.

Findings: The product is at a minimum height of 58cm with the handle, and 100 cm maximum with the handle.

Handle: the product is 13cm long, and 12cm wide. The diameter of the stick is 2cm.

Small wheel diameter: 5cm, large wheel diameter: 12.5cm. The circuit box is 20cm long and 10cm wide, and the handle top diameter is 10cm. Mass with all components and wheels: 1.23 kg

Illuminate dark room with flashlight: possible, range is minimal.

When an iPhone 5s is charged at a wall adapter (on grid) of 1A, it has taken 3 hours, whereas the device has taken 5 hours and 42 minutes due to its inconsistency, and the circuit box has heated.

When charging a HP laptop by 1A (on grid) it has taken 5 hours, whereas the device reached 37% in 7 hours and 23 minutes, before dying. This indicates a limited storage capacity, and slower charging rate.

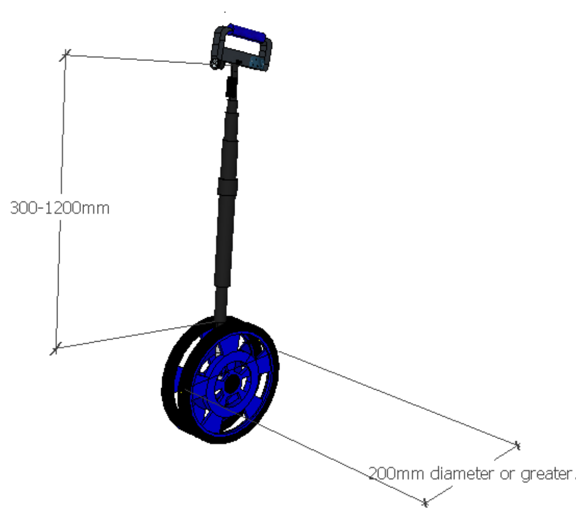
Evaluating the product against the design specification

Specification Point	**Met Yes/No**	**Justification**
Function- Generates 10V and 10W through a mechanical system like crank or wheel system to charge phones and other devices like laptops.	Partially 3/5	The max voltage generated to charge is 220V, and the generator can generate 12W, enough to charge phones and laptops. However, the charge capacity and rate are low. The circuit is inconsistent and does not charge at times (reliability). However, the solar panel and battery charger made the product much more effective at power generation and storage.
Materials- Must be light weight to correspond with **portability and comfort points**. **Low weight** is needed to allow the target market to **adapt** to movement for spontaneous power generation.	Yes 4/5.	The product is lightweight and adaptable and easy to hold using the 3D printed handle, and easy to adjust telescopic stick. Yet the wheels cause a disturbance in weight distribution. This makes movement difficult at times.
Manufacture- **Circuit is established including the needed wires dynamos and sockets, then modern high tech manufacturing methods such as a CNC router or 3D printing are used for aesthetics, insulating, and encasing the circuitry** with preset colored plastic	Partially - 3/5.	Not enough 3D printed items for modern aesthetics. Aesthetics, is hindered by tape and zip ties being used extensively. Wheels are too large and loose and even fall off at times. The telescopic stick is very loose and extends out mistakenly.
Compactness (Dimensions), Minimum length **of 15cm** to allow spacing for hands and components to fit in, no longer than **50cm,** when fully adjusted to minimum length and folded in order to fit an average **backpack** used by the target Market. **No wider than 30cm. Must cater to 50th female to 95th male percentile in height.**	Partially – 3/5	Minimum length is 58cm, maximum is 100cm. It can fit a backpack, yet not entirely as it slightly juts out. Circuitry box is too large, requires PCB to keep it small
Mass and portability. Minimum mass 0.3Kg, maximum is 0.8kg. This is needed for ergonomics and catering to target market needs.	No 2/5.	While it does feel lightweight, its mass is 1.2kg. The product specification is too unrealistic, as it relies only on the use of lightweight plastics. Uneven weight distribution at top, making it unstable at the bottom.
User/ Target Market- Portability, ergonomics, dimensions, aesthetics.	Partially 3/5.	This can only be met through the other specifications, half of the people in the user trial felt that the product needed improvement. Portability is mediocre based on above spec, the dimensions are not met. Yet aesthetics are poor, but ergonomics are met strongly.
Anthropometric measurements applied to handle (min 50th female percentile, maximum 95th male for hands). Compactness and low weight are to minimize burden of carrying.	Yes 3.5/5	The handle caters to the 50th female up to the 95th male percentile, as users stated it felt comfortable, however, the users needed to hunch over and moved in a stiff way, talking short unnatural steps as the construction is frail.
Safety and Environment	No 1/5	Larger wheels keep falling off, adapters can be exposed to water, wires are outside device and exposed.
Aesthetics**- Detailed fabrication that includes sleek curves, as well as polished and glossy surfaces with modern and bright color patterns (blue and black, red, orange and purple, etc.) chosen through CAD software.**	No 1/5	Product appears 'makeshift' as zip ties and tape makes it appear less professional. Very boxy structure overall, which opposes the need for curves and modern aesthetics. Color of the telescopic stick is out of pattern according to target market. However, the users did enjoy the use of blue on the wheels.
Cost- 20-50 (US). The user's dependence on technology is an expensive lifestyle that relies on high quality systems. 3D printing and precise fabrication would be costly at a massive scale, taking into consideration the long term energy generation. This is counterbalanced as the demand for clean	Yes 5/5	The majority of the people in the user trial (10 out of 20) recommended the price range of 20-30$, which is in the cost price range of the specifications, leaning towards the lower-moderate side.

energy and accessibility would be hindered at high costs, which mean less sales.		

Possible Improvements to the solution

Strengths	**Weaknesses**	**Improvements**
Wide variety of charging methods, integrating both passive and active methods of charging. The maximum voltage is 220V, and the USB and 3-pronged adapter allows the user to charge a wide variety of devices.	The rate at which devices are charged is low, so this reduces efficiency. The circuit is also unreliable. The charge capacity is low.	Use a better motor, larger solar panel, and a PCB to compact the circuit and organize current. Larger batteries are needed to charge for longer and for faster overall. (Series circuits maximize resistance, and reduce energy consumption as there is less, and parallel circuits are the opposite. A compromise is needed.
The handle is comfortable, and the telescopic stick is adjustable which caters to the user's height required.	The telescopic stick is too unstable and dismantles easily, movement is slowed because the height of the stick does not allow one to fully extend arm, but locks user in rigid posture.	Use a more rigid, well-constructed telescopic stick. It should also be longer in max height to ensure that it is extended easier. When designing, the tilting of the device needs to be taken into consideration.
Easy access to charging on the move due to USB.	User is forced to stay close to the device while it charges, otherwise the wire is detached and the phone (or laptop is detached.	Placing a pouch for laptops, and phones towards the topside of the handle.
Circuit is rigid and secure onto the device and is stabilized.	The circuit box is stable yet causes awkward weight distribution and takes up too much volume. The wires that extend from the generator to the circuit are exposed.	The use of a telescopic stick that allows for the movement of long wires up to the handle. The final design element where the appliances are added to the handle is reused, yet strengthened with acrylic to avoid breaking (more robust).
The lamp allows for good visibility at night	Not adjustable in position	Placed under handle and is adjustable in direction.
The device takes up a small amount of volume and can fit in medium-large sized backpacks and other types of bags.	The device will only fit in select backpacks, and may jut out.	Use a telescopic stick with the least minimum height (must correspond with maximum height).
The two wheel system allows for easy adjustability.	The wheels are unstable due to the motor.	3D print wheels that fit the axles tightly and are secure.



The impact of the solution on the target audience

With the specification serving as a method to address the target market's needs, it has appeared that the extent to which the target market's needs has been met by the product is not very much, but rather only to a certain, yet limited effect. The product was created so that the energy created by the body would be highly efficient in allowing the person charge their electric devices. The design brief stated that the increase in dependence on technology is to the most of the world' population, hence the choice to expand the target market was made. The research that was needed to form the design brief also emphasized that the device needed to address this global need would need to cater young adults and adults of both gender, more so than elderly, as the elderly are less reliant on technology. Therefore, the more the product's properties caters to the mass (0.3 to 0.8kg), compact dimensions, and ergonomic needs of the target market demonstrated in the design brief, the more accessible the product would be. Moreover, ergonomics is a crucial part of research conducted, for it affects the adaptation of the product by the target market, which resulted in catering handle and product design to work from the 50^{th} female to the 95^{th} male percentile. The more applicable the ergonomics is to the audience, the more adaptable and is easier to use. However, due to the product not entirely meeting the specifications, the impact the product would have on the target is not very much. This is caused by the weaknesses such as the slower pace a person would have and that they would be forced to remain near their phones when charging. Furthermore, the fact that the circuit is not very reliable, nor charges for long enough, and is not rapid further shows that the product isn't only ergonomically unsuitable, but is also functionally ineffective and inefficient at allow the user to adapt to the product or long term use. The application of science, specifically Faraday's law, is needed to help improve the experience. While considered ineffective, the device can and does charge electronics when needed, showing the potential change as a prototype. With the ineffectiveness and limited adaptability and poor construction, it does not completely comply with the goal of maximizing the kinetic energy to produce electricity. The products limited desire, limits the extent of effect on the target market. This once again partially solves the issue. However, if the improvements and feedback from the testing methods were applied, it would allow for full adaptation by a wide variety of people. The prototype improves the target audience's situation by allowing them to take full advantage of the surroundings to counteract the immobility and battery loss that comes from the extensive use of phones and other devices. It even economically improves the situation as a successful product allows the users to remain off the grid, with the ability to rely on the boy's mechanical energy to produce electricity. The product's adaptability, ingenuity, and iterative nature of dynamos and generator act result in a higher availability of electrical energy, which remodels a global system which relies heavily on electrical energy with the expansion of electrical innovations. The product in terms of functions relies on scientific principles researched in the design brief, where mechanical systems were developed further to convert mechanical energy to electrical energy. Furthermore, the product ergonomically and in terms of dimensions meets the requirements, However, unexpected issues have arisen which contradict the highly ergonomic and compact (poor body-gadget coordination in movement). Furthermore, the lack of modern aesthetics and precise innovative fabrication techniques like 3D printing were limited, placing the product at a disadvantage as predicted in the limitation. Therefore, it can be concluded that the product partially yet poorly meets the specification. The possible negative effect of this device's scientific and technical innovation is that increases the reliance on technology, which remodels global systems and social standards, as body movement can compensate for the charge lost during charging. Hence, a more technology based, less social lifestyle can be promoted. Also, a possibility is that movement pace may much slower than regular standards, as the product would be kept closely if highly successful. Finally, a physical negative effect is that any damage sustained to the product which exposes the circuit can shock its user if the inverter is used.

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