Mission Folder: View Mission for 'Baby cAir'

State	International (Not US Territories or DoDEA/DoDDS)
Grade	9th
Mission Challenge	Food, Health and Fitness
Method	Engineering Design Process
Students	MagicDragon sumitac17 brainstorm r123456

Team Collaboration

(1) Describe the plan your team used to complete your Mission Folder. Be sure to explain the role of each team member and how you shared and assigned responsibilities. Describe your team's process to ensure that assignments were completed on time and deadlines were met.

The Baby cAir team is made up of four ninth grade students attending Shanghai American School Pudong: Sumit Chandra (sumitac17), Isaac Xu (Magicdragon), Linden Li (brainstorm) and Rena Jiang (r123456).

Upon the beginning of our brainstorming process, a product to target air pollution was one of many ideas. To decide which idea would be the best to develop, our team took a vote through the analysis of each idea's uniqueness, feasibility, and community benefit.

The creation of our project was done through a pre-determined process:

1. Background research — problem definition
2. Preliminary marketing survey — understanding the voice of the customer
3. Prototype design and construction (including discussion with experts)
4. Second consumer feedback round
5. Design improvement and review
6. Prototype construction and testing
7. Data collection and design verification/analysis
8. Mission folder construction

Throughout the course of this project, team members were allocated assigned roles and responsibilities. Each person was assigned a specific section of the mission folder to complete for greater efficiency and equal contribution. Once the work was done, meeting time was used to review each other's ideas and provide personal feedback.

- Sumit led each meeting to ensure efficiency, wrote the agenda for each meeting, contributed initial design, and wrote part of the Engineering Design
- Rena took meeting minutes, drew many prototype design models, and finished the Engineering Design
- Linden specialized in research, led the testing process of the initial product and wrote the Benefit to the Community section
- Isaac led the and built the prototype, programmed the feedback loop, and wrote the Team Collaboration section

Because of other outside commitments, we realized that in order to finish the project in a timely and effectively manner, it was necessary to help each other with out responsibilities. Although specific assignments were designated to certain team members, sections were completed and reviewed by at least two team members.

At the beginning of the project, we created milestones to allow sufficient time to complete the mission folder. To ensure that meetings were productive, an agenda was set up and communicated through email before each meeting. During the meetings, we followed our agenda to ensure we covered every topic and did so efficiently. Previous meeting minutes were reviewed, and new action items implemented with new due dates to pace our progress. The community of respect and mutual responsibility that we instilled in our team ensured the quality and educational completion of this project.

Engineering Design

Problem Statement

(1) What problem in your community did your team try to solve? Why is this problem important to your community?

As the world shifts to an era of rapid economic growth through means of industrialism and infrastructural investment, our environment begins to reveal the repercussions our decisions have had. For Southeast Asian countries, most notably China, the issue of air pollution has arisen as a pressing health issue, and has provoked attention at an international level. The Environmental Protection Agency (EPA) defines healthy environments as an air quality index (AQI) of less than 50 (Environmental, 2014). China is notoriously known for its extreme pollution levels—at one point in 2013, the AQI reading exceeded levels of 500 and broke the scale of pollution reading ("Beijing Air", CBS News).

Polluted air in China poses serious health risks to everyone, but especially to younger children. Infants are most susceptible to the harmful effects of pollutants due to their immature and developing respiratory systems. The child's nervous, immune, and respiratory systems all undergo rapidly development until around the age of six. Until that

stage of increased maturity, the systems are not developed and are thus highly vulnerable to external factors. This beginning stage of development in human life is of utmost importance; exposure to high pollution levels can have long term, adverse effects on a child's life. Pollution has been proven to exacerbate existing health conditions, including asthma, and can induce harmful illnesses such as chronic cough bronchitis in children.

Because our community is now cognizant of the health effects of air pollution, industrial air filters have become ubiquitous among Chinese households. Household air filters are able to purify air inside to some extent, but cannot protect people in outdoor environments. This presents another problem in itself—babies are thus forced to use masks with insufficient filtration systems during outdoor activities, and cannot be fully protected from pollution. It is of greatest importance for the Chinese community to find a solution to prevent children from life-threatening diseases at such young ages. Children must be given their inalienable right to grow up in a safe, clean environment, without the health complications that come with early exposure to dirty air.

(2) List at least 10 resources you used to complete your research (e.g., websites, professional journals, periodicals, subject matter experts).

1. Ritz, Beate, and Michelle Wilhelm. "Air Pollution Impacts on Infants and Children." UCLA Institute of the Environment and Sustainability. Ed. Arthur Winer. UCLA, 2008. Web. http://www.environment.ucla.edu/reportcard/article1700.html.
2. Goyette, Braden. "More Air Pollution Deaths Per Year Than From AIDS, Malaria: UN." The Huffington Post. TheHuffingtonPost.com. Web. 28 Feb. 2015. http://www.huffingtonpost.com/2013/04/09/air-pollution-deaths-green-energy_n_3045828.html.
3. Ms. Li Wang, Engineering Fellow at Honeywell Technology Solution China
4. "Newborns Are More Susceptible to DNA Damage from Pollution than Their Mothers." News-Medical.net. 24 June 2004. Web. 28 Feb. 2015. http://www.news-medical.net/news/2004/06/24/2758.aspxhttp://www.news-medical.net/news/2004/06/24/2758.aspx.
5. United States Environmental Protection Agency. (2014). AQI, Air Quality Index [Brochure]. Research Triangle Park, NC: Environmental Protection Agency. http://www3.epa.gov/airnow/aqi_brochure_02_14.pdf
6. Jun Xu, Ph.D, (aeronautical engineering) Honeywell Technology Solution China
7. "Vital Protection for Newborn Babies!" SafeAir. Herstein Cassuto. Web. 28 Feb. 2015. http://www.safeaircover.com.
8. Knapton, Sarah. "Common Cold Really Is Triggered by Chilly Weather, Yale Scientists Find." The Telegraph. Telegraph Media Group. Web. http://www.telegraph.co.uk/news/health/11325347/Common-cold-really-is-triggered-by-chilly-weather-Yale-scientists-find.html.
9. "Beijing Air Pollution off the Charts." CBS News. CBS, 13 Jan. 2013. Web. 7 Jan. 2016. http://www.cbsnews.com/news/beijing-air-pollution-off-the- charts/.
10. Nordqvist, Christian. "2 Million Die Prematurely Each Year Because Of Air Pollution." Medical News Today. MediLexicon International. Web. 28 Feb. 2015. http://www.medicalnewstoday.com/articles/53576.php.
11. "Air Pollution Particulate Matter." GreenFacts. GreenFacts, 25 Nov. 2015. Web. 3 Jan. 2016. http://www.greenfacts.org/en/particulate-matter-pm/.
12. Yao (Frank) Li, Senior System Engineer at Honeywell

(3) Describe what you learned in your research.

In recent years, the increase in carbon emissions from developing industries has released harmful pollutants in the air. This mixture of particles, known collectively as particulate matter, lay suspended in the atmosphere. Though some classifications of particulate matter, such as dust, may be typically found in air, particle pollution includes pollutants that are detrimental to health when inhaled. Each particle is classified by its diameter in micrometers; among these, PM2.5 and PM10 are the most common and debilitating when inhaled. Because the particles are so small, they hold high potential to infiltrate bloodstreams and the lungs. Air pollution now kills 5.8 million people a year, and according to the United Nations and The World Health Organization, more than AIDS and malaria combined.

The extent of influence that air pollution has on recreational activities has increased significantly. Days with high pollution levels, classified quantitatively as high levels of PM 2.5 in the air, now leads to cancellation of outdoor activities. High air pollution in China has worsened to where educational and recreational activities are postponed in the interest of health. In fact, an AQI of one hundred, levels considered excessively high in the USA, is considered a below average day in China. Levels in Shanghai had reached over 400 in the winter, with Beijing breaking the chart for a second year in a row at 800.

The rise of air pollution as a global health issue has had significant health effects, especially to sensitive children and elders. In the first six years of a child's life, the immature respiratory system is in a stage of rapid development and thus extremely vulnerable to external influences. According to the World Health Organization and the United Nations, two and a half million premature deaths a year are caused by air pollution globally. Due to the respiratory development in infants, they are more susceptible to air pollution's effects. Unlike the mature respiratory system of adults, the large surface area of children's lungs requires more air in each inhalation. Recreational activities in elementary schools, moreover, give children greater exposure to the outdoors. In a 2001 Center for Disease Control and Prevention (CDC) study published in The Journal of the American Medical Association, data showed that as pollution decreased, asthma attacks became less common. The Children's Health Study, moreover, conducted a long term research project that involved over six thousand children through the time span of eight years, split into twelve groups all exposed to different levels of pollution ("Ritz, Beate, and Michelle Wilhelm, 2008). The group of researchers, all affiliated with the University of Southern California, found that exposure to pollution resulted in various short and long term health effects. These included acute respiratory illnesses and worsened asthma attacks, along with the development of chronic respiratory diseases in the long-term. It is therefore scientifically evident that exposure to air pollution is clearly linked to detrimental effects on health.

Part of our research involved looking at previous solutions to encourage innovation and to prevent the creation of a duplicate product. When assessing effective solutions to the problem of mitigating the severe heath effects caused from air pollution in infants and toddlers, several factors come into consideration. There were two ideas that stood out to us in our research: an "air shield" by Dominykas Budinas, and a "child transport air filtering system by "Hal D. Koch." Both ideas illustrated the importance of an effective filtration system in a stroller. In addition to filtering, each cover completely enveloped the stroller to ensure that no external air particles infiltrated the pure environment.

In addition, we conducted interviews with possible customers to see if there was a need for such a product and what they thought an ideal product would be like. Most mothers stated that the product had to be both aesthetically appealing and cost effective, as well as being baby-friendly. We learned that the product must be designed to meet the needs of the customer, and so we realized that a consumer's voice was required for the success of the project.

Experimental Design

(4) Develop a design statement. Be sure to describe what exactly your device should be able to do. Do not describe HOW it's going to do what it needs to do.

The final product should allow parents take their child out for a stroll with no worry about pollutants harming the baby. Babies should be able to stay in the enclosed environment without any risk of inhaling pollutants. The environment should be able to sustain healthy levels as stipulated by the EPA. Our product specifications (elaborated in attachment) are as follow:

- Filter PM 2.5, at an efficient rate, to a target of =50 AQI
- User-friendly
- Healthy air flow inside the cAir Cover
- Easy access for the baby
- Comfort for the baby
- Easy assembly and disassembly
- Easy mount/dismount
- Fan with rechargeable/replaceable batteries

• Different fan speeds
• Waterproof

(5) Determine the criteria for a successful solution and identify constraints for your design. Discuss what the device must have in order to accomplish its job and the restrictions of the device (i.e. the size, the cost, the weight, etc.).

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Because the cAir Cover targets a marketing audience of parents with young children, the process of generating a model for the stroller cover involved considerations of safety and comfort. In addition, the efficacy of the product in filtering out harmful pollutants must be ensured. Thus, the following design requirements must be met in order to facilitate the selection of a proper model.

1. The product must protect infants and toddlers from harmful pollutants by providing an internal environment with an AQI under 50.

According the EPA, an air quality index (AQI) in the range of 0-50 is an ideal environment with little respiratory risks. Thus, in the design of our product, we must ensure that the purified environment does not exceed an index of 50.

2. The internal temperature must be kept at a comfortable, controllable degree.

The child's immune system becomes more susceptible to disease in cold temperatures. A study by Yale University has shown that when the nose is at a low temperature, the immune system's ability to fend off diseases is significantly weakened. For our product, we seek to ameliorate the issue of air pollution without bringing new health problems in the process. Hot air, moreover, can become easily trapped by the cover. An enclosed space with a high temperature leads to further risks in babies' health.

3. The parent can monitor the inside environment at all times.

We are currently developing a feedback system that displays the inside air quality and will automatically change the fan speed inside the stroller to regulate safe air pollution levels and after this temperature levels. It is not fully developed yet, but we are currently using the Arduino programming software to further develop it.

4. The stroller cover must be versatile, with an ability to fit on a variety of strollers.

The possible pool of consumers for our product, families of young children, all have strollers of different designs. Thus, the product must be able to fit these different shapes to solve the problem on a larger scale. To prevent a heavy cover from falling and possibly asphyxiating the baby, the product should be able to stand up without constant repair of the structure.

5. In order to ensure comfort, the adult and child must be able to easily see each other at all times.

Enclosure in small, dark environments can easily scare the child and make them reluctant to stay in the cover. Long exposure to darkness, moreover, dilates the pupils and makes the infant's eyes more sensitive to light. The child should be able to see its environment, and be accessible to the parents' sight.

6. The cover must be easily assembled, removable, and portable.

Consumers will likely not use the product if it cannot be easily assembled and taken apart for their convenience. On lightly polluted days where the cover is unnecessary and bulky, the product should have easy, compact disassembly.

(6) Identify the relevant variables you will use to test your prototype or model and explain how you will measure your variables.

The relevant variables in this product are the AQI in and outside of the cAir Cover, fan speed, inner temperature, and the duration of how long it takes to bring the inside AQI below 50. AQI is quantified on its own scale and is measured with a PERIC AQI Monitor. The PERIC AQI Monitor came integrated with both temperature and AQI measuring capabilities. Fan speed is measured in five possible settings, with level one being the lowest speed and five being the highest. Finally, duration was measured with a stopwatch to quantify how quick it takes for the cAir Cover to make a safe environment.

Our independent variable, when testing, was the fan speeds, while we measured and recorded the AQI, temperature, and the duration of time it took for the AQI levels to reach below 50.

Build Prototype or Model

(7) Develop a design and list the materials you used in your design. Include technologies you used (e.g., scientific equipment, internet resources, computer programs, multimedia, etc.).

1. The air filtration process

Our design's air filter is based on those used by large commercial filtration brands, including IQAir. Inside the large filters are ozone-free fans that propel winds through a high efficiency particulate air filter. The resulting air, after entering the filter, comes out clean. To fit what was supposedly a large filtration piece in a small cover, we attached an ozone-free fan to a HEPA filter, and embedded it into the device. Despite the device being significantly smaller than the air filters found in Chinese residences, it does not lack efficiency or effectiveness in purification.

2. Controlling interior air temperature

To prevent the inner temperatures from getting excessively cold, the product contains fans with variable speeds. As lowering pollution is the priority, the filter will stay on until it reaches a sustainable index in the healthy range. After it has attained a certain AQI for a period of time, the fan speeds will automatically change to a lower degree to prevent further temperature drops. In addition to changing fan speeds, we considered using a cloth conducive to heat. With our multi-layered cover design, heat is able to easily enter the enclosed space, but cannot escape.

3. Durable structure and proper fitting

For the structure, we sought to use a durable and flexible material for easy disassembly Steel pipes prevented the flexible fitting of the cover onto the structure, but provided robust stability. However, they could not be easily bent to the shape of our initial design. Thus, with steel rods hindering the cover from being fit on most strollers, we decided to use PVC pipes. The sacrifice in durability from steel rods led to greater flexibility and a more distinct shape of the cover.

4. Field of View

The babies' ability to see outside from the cover was a large contributor towards our product's promise of comfort. We decided to implement a thin layer of transparent film at the anterior of the cover. To allow the mother to see the baby, moreover, we extended the film towards the top of the cover.

5. Shape of the design

The design must have a shape that is not too large, as the filter can only reach a certain area. As stipulated in the design requirements, the stroller must also be able to fit on a large variety of strollers.

Our final prototype of the design is a cover that will enclose the entire stroller leaving the wheels and handlebars exposed. The shape of this cover is a rectangular prism similar to a stroller rain cover. This cover incorporates three layers with plastic sandwiched between fabrics. On the side of the bubble are the filters. The proposed structure is made of PVC pipes to shape the entire Cover. A small leak in the bottom is left to facilitate airflow.

Material List:
- PVC Pipes
- Pipe connectors (bent and straight)
- Curtain cloth for fan jacket material
- Transparent plastic
- HEPA Filter
- Fan with changeable fan speed
- Zipper
- Velcro
- Fan battery that can be attached

(8) Explain how you built your prototype(s) or model(s). Include each of the steps in your process.

The building of the prototype began with an initial, detailed plan drawn out with a sketch (Refer to Picture 9 – Sketch). It was ensured that all facets of the prototype conformed with our design standards and the voice of our consumers. As mentioned earlier, part of the research process involved the interviewing of mothers to get input on what they believed should be integrated in a pollution cover.

Based on our sketch, a crude prototype was built with our readily accessible materials, including bamboo and rope (Refer to Picture 2 – Prototype 1). We took this prototype to Ms. Wang Li, an engineering fellow from Honeywell. Her expertise on building filters helped us to work on the efficacy of our fan system; she had already been working on products that could filter out toxic chemicals and pollutants. During our time with Ms. Wang Li, we learned some valuable information about efficient filtering (Refer to Attachment #6 – Wang Li Interview) that we later incorporated into our product.

After experience with building our first prototype and the advice of a specialist, we drew up some more sketches, and designed the cover. Fans were selected based on the volume inside the product that needed to be purified.

The product's materials and construction was very demanding—our parents advised that we find a tailor to make it for us. It required the use of special cloth and sewing to integrate the fan inside of the cover. Most tailors, however, were unwilling to do the work due to its complexity and uniqueness. Although many tailors did not accept the job, we did not give up. After the tailor finished making the 3-layered cloth we had designed, we attached the cover to the stroller and inserted the changeable fans, and the batteries that we purchased.

Test Prototype or Model

(9) Describe the data you collected and observed in your testing (use of data tables, charts, and/or graphs is encouraged).

Unfortunately, on the days we planned to run our procedure, the AQI readings were the best they had been all month. At that point, we decided this was another experimental opportunity—to simulate the effects of a bad Shanghai day, we had to artificially pollute our environment.

We tried burning paper, but levels reached un-realistically high levels and could only be exposed to one fan. Through research, we found that the smoke released from burning oil contains PM 2.5. From this, we placed a small amount of oil on a pan, and turned the stove on. We continued to monitor the pollution and began conducting the tests when the pollution in the room reached an AQI around 100.

Before the tests, we calibrated the environment by making sure that the AQI readings both inside and outside of the stroller were similar (Refer to Picture 5 - Testing). We verified this by using two PERIC AQI monitors, one inside the product and the other outside. We opened the flap on the front of the cAir cover when calibrating, simulating when the product was not in use.

Once our calibration was finished, we made sure that we recorded the outside index and temperature. Then we set the fans to the required speeds (depending on which test we were running) and sealed off the product through zipping up the flap, simulating when the product was in use. When the inside reading had stabilized, we recorded what the reading was, the temperature inside, and the time it had taken to stabilize. We did this for 2 of the 5 fan speeds (3 and 5), in order to save time while still obtaining enough basic information on the efficiency of our product. Our product seemed to work very well, always reducing the PM 2.5 levels by at least 50% within 25-180 seconds, depending on the fan speed and to less than 50 parts/million (AQI), regardless of fan speed (Refer to Picture 6 - Testing).

For the data and report, refer to 'Attachment #3 - Test Report'.

(10) Analyze the data you collected and observed in your testing. Does your data support or refute your design statement? Do not answer with yes or no. Explain your answer using 'Our data supports/refutes the design statement because...'

your design statement? Do not answer with yes or no. Explain your answer using 'Our data supports/refutes the design statement because...'

The data we collected through our testing supports our design statement, as our product was efficiently able to filter PM 2.5 at all fan speeds. The cAir cover always filtered at least 50% of the PM 2.5 in the air, reducing the levels to below an AQI of 50. 50 is also the AQI level that is considered healthy by the Environmental Protection Agency (EPA).

On the highest fan speed of 5, the air quality index was improved from 124 to 35 in a matter of roughly 20 seconds. The validity of the results was verified through multiple tests. At a lower fan speed, the pollution levels still were reduced by about 50%, in roughly three minutes.

(11) Explain any sources of error and how these could have affected your results

The first source of error was that the monitors that we used to read the air quality index could read the pollution with a ±10% margin of error. Although this means that some of our reading may not have been exact, through the trend of the data we collected, we would still get very similar results.

The next source of error we came across was that the filter, after a certain amount of tests was not able to maintain that same level of filtering. We did not know what the HEPA filter's 'life' span was. This would change our data a small amount.

The sources of error involved in our testing only had a minor effect on our results, so we decided that it was not required to redo our testing.

Drawing Conclusions

(12) Interpret and evaluate your results and write a conclusion statement that includes the following: Describe what you would do if you wanted to retest or further test your design. Evaluate the usefulness of your prototype or model. What changes would you make to your prototype or model for the future, if any?

Our design includes the following: a cover for strollers that filters air pollutants through a HEPA filter attached to a fan. When used, our new product minimizes the effects of air pollution while creating a comfortable setting for the child.

Through our experiments, we conclude the product design meets, and exceeds our aforesaid requirements. It demonstrates an ability to filter out pollutants, especially particulate matter. The temperature and noise level can be easily controlled.

If we were to retest our current design, we would test the life span of the HEPA filters, test the product in a real environment, and test it on multiple stroller designs. We would also do many more tests with parents and children.

If our product would be released on the market, we believe it would become a popular product among families.

We believe there is room for improvement. The product could be better sealed, and thus more efficient in filtration. To make it easy to assemble, we will incorporate a folding design in which the user unfolds the product and straps it onto stroller. The new material will be more transparent, allowing for a brighter interior. It will have rechargeable batteries charged by the movement of the wheels, or possibly by solar panels. Finally, it will filter both PM2.5 and toxic gas because we will combine a carbon filter with a HEPA filter. The product at its current state fulfills our design requirements to the most basic extent – a future development would extend the capabilities of our device.

We are also currently developing a feedback system that will display the inside temperature and AQI, as well as algorithms that will automatically change the fan speeds to ensure a safe environment for the child. We may also incorporate a possible controlling application that can be accessed through smartphones.

Uploaded Files:

- [View] **Attachment #1 - Test Report** (By: sumitac17, 02/24/2016, .docx)
  A detailed test report with descriptions and data of our experiment to test the effectiveness of our product.
- [View] **Attachment #2 - Safeair Cover comparison** (By: sumitac17, 02/24/2016, .docx)
  Attached is a table that compares our product to another not yet released on the market, the Safeair cover.
- [View] **Attachment #3 - Product Spec** (By: sumitac17, 02/24/2016, .docx)
  Detailed Product Specifications for the cAir Cover
- [View] **Attachment #4 - Wang Li Interview** (By: sumitac17, 02/24/2016, .docx)
  Our interview with questions and answers with an engineering fellow at Honeywell, Ms. Wang Li
- [View] **Picture 1 - Building** (By: sumitac17, 02/24/2016, .jpg)
  Our preliminary building of our first, crude, prototype
- [View] **Picture 2 - Prototype 2** (By: sumitac17, 02/24/2016, .JPG)
  A picture of our finished, first prototype
- [View] **Picture 3 - Final Product** (By: sumitac17, 02/24/2016, .JPG)
  A picture of our 2nd, tailor made product with attached fans and filters. This product was used in the testing.
- [View] **Picture 4 - Group Photo** (By: sumitac17, 02/24/2016, .jpg)
  A picture with the team standing behind the product, the cAir Cover.
- [View] **Picture 5 - Testing** (By: sumitac17, 02/24/2016, .jpg)
  Before testing, with the cAir Cover not in use, it can be seen that the AQI is the same inside and outside the product.
- [View] **Picture 6 - Testing** (By: sumitac17, 02/24/2016, .jpg)
  While the product is in use, it can be seen that the cAir Cover is working efficiently
- [View] **Picture 7 - Outside Product Description** (By: sumitac17, 02/25/2016, .jpg)
  A description of the features that can be seen on the outside of the cAir Cover
- [View] **Picture 8 - Inside Product Description** (By: sumitac17, 02/25/2016, .jpg)
  A picture describing the inside features of the cAir Cover
- [View] **Picture 9 - Sketch** (By: sumitac17, 02/25/2016, .jpg)
  Preliminary sketches of our first prototype

Community Benefit

(1) How could your design help solve your problem and benefit your community? Describe next steps for further research/design and how you have or how you could implement your solution in the future.

The increasing, and now pressing, issue of air pollution as a health issue has not been targeted with efficient solutions. Because of its innovative, unique design, the cAir cover's functions reduces reduces infant exposure to pollutants during outdoor activities. Our community has seen a steady decrease in the amount of kids involved in recreational activities in the outdoors. Chinese parents and schools do not want to risk the respiratory health of their children by exposing them to the polluted atmosphere. Because of our team's mandate to give children an environment of purified air, the younger sector of our community should be able to enjoy nature with little risks. Children hold the basis of our future generation, and it is thus a priority to make sure that they are able to grow and become empowered citizens. It is impossible to achieve this if children are denied their inalienable right to clean air, without having to deal with the troubles of health issues that could be caused by exposure to unclean air at an early

age.

Babies, however, are equally susceptible to air pollution as the elderly. The concept behind this product, an purified environment could apply to other sensitive groups. Due to the many uses and potential extensions the cAir cover brings, we see our design as an essential tool in the health industry's near future. Our pollution purifying concepts benefits people in their daily lives by providing them with access to clean air.

We seek to extend our consumer studies to obtain feedback for improvement, and to release the cover into the health industry in the near future. We seek to use a readily available resources to further and create a second generation of this product. As mentioned above, our aim for the second-generation product would be to extend the scope of our pollution purifying technology. For the stroller cover, we would seek to provide parents with a more user-friendly interface, giving them easy monitoring of the interior conditions. To reach a greater amount of people in the community, moreover, we are looking to adapt the design to fit all strollers.

It is with great honor that we present this product to our community. It is a device that is cheaper than industrial filters and incorporates the concept of air filtration into a design for a more specific audience. Parents will now be able to use this product to walk their children even on polluted days.

We believe that our product can improve our future generation the lives of many other people.

Mission Verification

(1) Does your Mission Folder project involve vertebrate testing, defined as animals with backbones and spinal columns (which include humans)? If yes, team must complete and attach an IRB approval form.

No

(2) Did your team use a survey for any part of your project? If yes, team must complete and attach a survey approval form.

No

(3) You will need to include an abstract of 250 words or less. As part of the abstract you will need to describe your project and explain how you used STEM (Science, Technology, Engineering and Mathematics) to improve your community

With China's economic growth making it an ever more influential actor on the global stage, the results of development resulted in a national health crisis. Among the people at risk are young children and infants, who, because of their immature respiratory system, are the most susceptible to pollutants. In the interest of providing children with clean air, our team has designed the cAir cover, a stroller accessory that filters out harmful pollutants during outdoor activities.

To create the product, we followed the eight steps of the engineering design process, from research to testing and design verification. Research covered the topic of defining problem, leading us to focus on young children. We decided to make a product that would efficiently filter pollutants in a baby's environment. Through interviews with potential customers and specialized technical experts, we improved our design. Our product is the result of constant improvement and integration of specialized suggestions, and boasts innovative filtration systems. The use of STEM principles, moreover, helped to enhance our designs from all aspects.

The cAir cover right now still remains in a state of active improvement. In our most recent plans for development, we are looking to widen the cover's scope to include a greater variety of strollers. We believe that our product has the potential to contribute to the healthy wellbeing of our young children in the community. It is essential that children, the basis of our future generations, are given a healthy environment to grow up in.

cAir Cover Test Report

Purpose of experiment:
In order to see if our product was actually able to reduce PM2.5 levels below 50 AQI, we needed to test our product's filtering efficiently. We tested our product on different levels of fan speed to see if the PM2.5 levels will be reduced below 50. While we tested for the filtering efficiency, we also measured the temperature to make sure the product will not cause the environment inside the stroller to be too cold. Finally we measured the amount of noise caused by the fan, because we wanted to see how much noise the fans would cause and if it would irritate the infant or not.

What:
We used many materials to test our prototype. Below you can see where we got them and their uses.

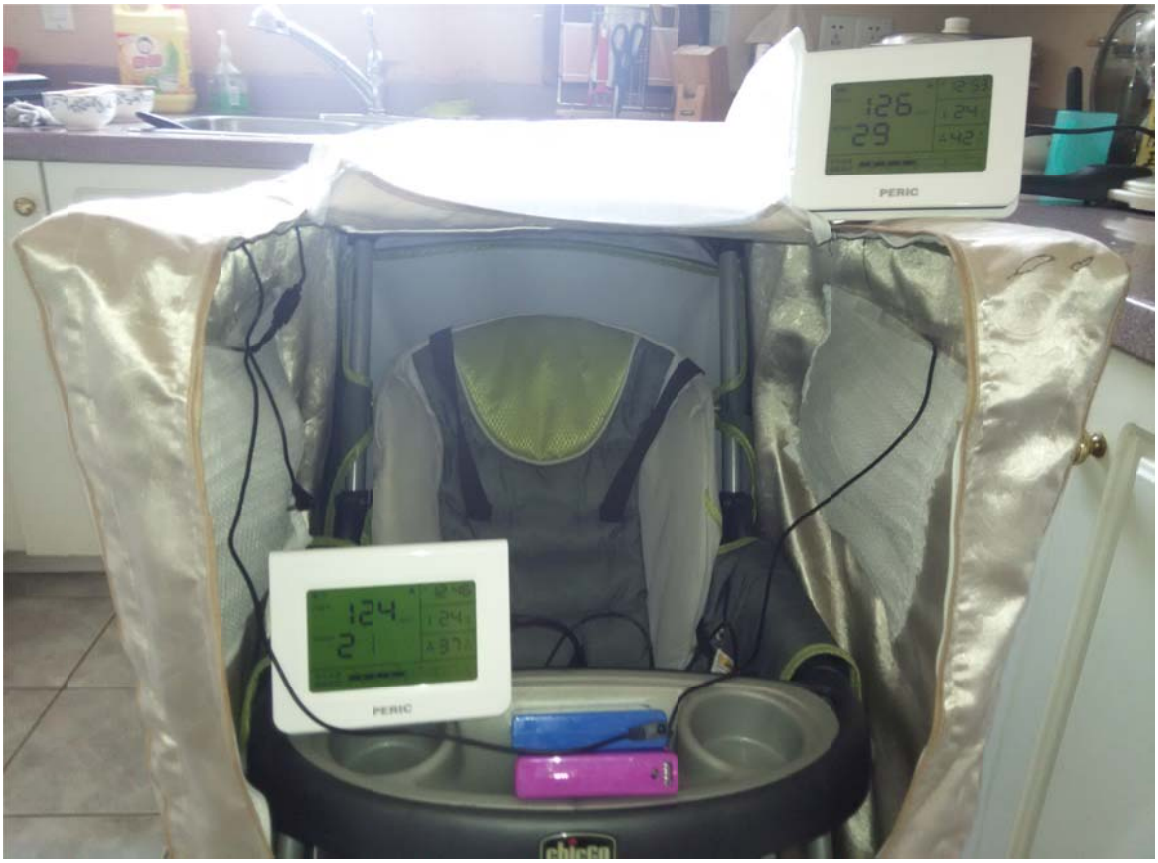
- Pan, Oil, Stove
- 2 PERIC AQI Monitors
- cAir Cover product
- Stroller
- Stopwatch

Procedure:
We waited for a polluted day to test our product, but when one did not come, we tried burning paper and letting the smoke waft through the fan. When we measured the amount of air pollutants using sensors, the sensors did not change or respond. We concluded that the sensors were broken because we have not used them in a while and we decided to try testing another day.

The following weekend we decided to try and test one more time. This time, we burned vegetable oil in a pan, creating a polluted environment in the kitchen. We placed a sensor outside and a sensor inside, so that we could see the difference between the air quality outside and the air quality inside. First, we waited for the amount of pollutants outside to match the amount of pollutants inside, because we needed to recalibrate the environment. When the amount of pollutants inside matched the amount outside, we enclosed the cover and turned on the fans. We had a stopwatch to measure the time it took to reduce the AQI levels to below 50.

Results:
The results were quite successful. Not only did the highest fan speed filter out the pollutants, but the lower fan speeds filtered them out as well. When we measured the temperature inside the stroller and compared it to the temperature outside, we saw that there was maybe a 1 or 2 degrees Celsius difference.

Fan Speed	Temp Outside (Deg. C)	Temp Inside (Deg. C)	AQI (PM2.5) Outside	AQI (PM2.5) Inside	AQI (PM2.5) diff.	Noise (dB)	Time of filtering (sec)
3	26	25	99	25	74	50	180
5	26	24	124	35	89	78	25



Before test, where AQI is bad both in and outside the cover (flap is still open)

Middle of the test, product is reducing AQI in stroller.

Comparison with competitive product: the "Safe Air Cover"

Safe Air Cover	cAir Cover
	Fan
Material protects against pathogens and pollutants. Rainproof, and breathable	Material water proof and dust proof, not breathable (still has sufficient air flow)
Material acts like a filter preventing pollutants and bacteria from getting into the stroller	Filter component which includes, fan, battery holder, and filter that can filter out PM2.5
No assembly required	Self assembly required
No batteries required	Rechargeable battery included
Filter out bacteria and pollutants	Filters out PM 2.5
Fits on almost all strollers	Fits on almost all strollers
Has to change the cover every once in a while	Requires self maintenance and might not stay clean
Only lasts about 10 days	Lasts about 1-2-months of usage

Product Spec for cAir Cover

- What it includes:
  - Two fan filter components
    - Fan
    - HEPA filter
    - Rechargeable Battery Case
  - The Cover
    - 1 openings:
      - One zipper opening on the front (facing the baby), so you have access to the baby and can take them out
  - Snaps for attachment
  - Comes in a Box
- Disclaimers
  - Might get cold depending on fan speed
  - Does not cause any other health hazards
  - Easy Self Assembly
- Self-assembly
  1. Take Each Component out of box
  2. Pull out the Cover
  3. Unfold Cover
  4. Put pipes in designated slots
  5. Connect certain pipes
  6. Place over stroller
  7. Velcro the flaps around the handles
  8. Enjoy
- Features
  - Portable
  - Waterproof
  - Clean Air
  - Transparent Window
  - Filters PM 2.5, $\leq$ 50 AQI
  - Doesn't irritate baby
  - Easy Access
  - Easy assembly
  - Easy maintenance
  - Light

Pros	**Cons**
• Waterproof • Healthy Air Flow • Filters PM 2.5 • Easy Access To Baby • Easy Self Assembly and Set Up	• Doesn't fit *every* stroller See Note • Might Get Cold • Needs Self Assembly and Self Maintenance

• Convenient • Comfortable for Baby • 5 Different Fan Speeds	

Detailed Description of Generation 2

Generation 2 of our project will be a better and more well designed version of our previous design. It will have a better seal, which means a better filtering efficiency. To make it easier to assemble, we will incorporate a folding design in which you unfold the Cover and strap it onto your stroller. We also may incorporate rechargeable batteries that are charged by the kinetic energy generated through the movement of the wheels. We are also currently developing a feedback system that will display the inside temperature and AQI, as well as algorithms that will automatically change the fan speeds to ensure a safe environment for the child. Also there will be minimized self-maintenance because the filter will last longer and the fan will be more durable. Finally it will filter both PM2.5 and toxic gas because we will combine a carbon filter with a HEPA filter. Overall this product will look better, work better, and sound better than the first one. I propose we call it the BABY AIR TANK, or something else that is cool.

Note - While it doesn't fit every one, it fits many variations

Q&A With Ms. Li Wang, Engineering Fellow at Honeywell Technology Solution China

1. **What material is recommended for this product?**
   For good air filtration efficiency, it should be isolated.
   The HEPA filter has a high resistance to air flow, so make sure that the fan and the filter are sealed properly.
   PMMA – Hard, transparent material that could be used, **not flexible**
   Use middle efficiency HEPA filter; with **good** sealing, and powerful fan to guarantee air flow
   Seal everything, besides the wheels
   Xiaomi air cleaner, disassemble it, use their frame and filter
2. **Would you recommend the 3M breathable Material?**
   It is not transparent, so include a window.
   The material might not be waterproof.
3. **Should we use one or multiple fans?**
   It is better to have one powerful fan so it is simpler and easy to work with
4. **What kind of filter should be used for this product?**
   HEPA requires high-power fan
   Take apart an air purifier and see how it works
5. **How do we make sure that our product is effective?**
   Testing the air filter using the particle detector inside the bubble, versus the outside air quality
6. **Do you see any flaws in our design?**
   No major flaws
   Wouldn't necessarily cause health problems
   Make sure that the material doesn't blow in the wind, which might cause safety issues by possibly hitting the baby
7. **What should we add to our design?**
   Functionally, it is good
8. **Do you think this is an overall safe product?**
   I think its okay, unless a malfunction
   Make sure supports are strong and safety aspects have been considered
   Make sure Fan will not reduce the temperature to dangerous levels
9. **Why do you think people would or would not buy our product?**
   Price should be around 500 RMB.
10. **Are you a parent and would you buy this product if you were?**
    Make sure it is visually appealing, and also not too expensive
11. **Should we focus on the crib or the stroller?**
    Good idea, but when the baby is sleeping there is already air purifier in the room
    Need to control the noise
    Using it on the street, the noise will not be too much of an issue
    Not a big need for the crib, but it could also work, as it will require purifying a small space

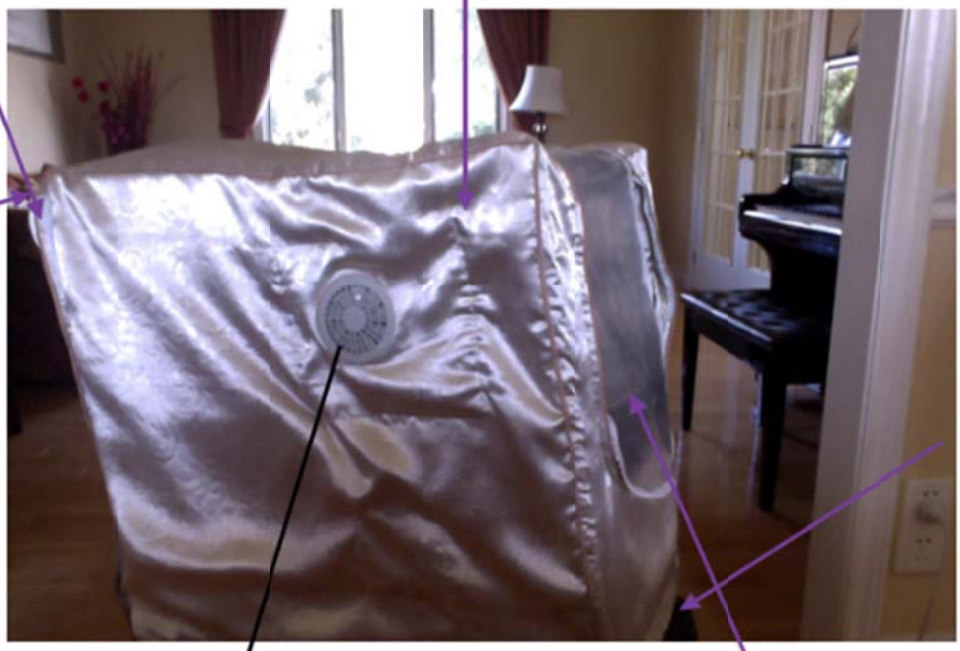
12. **What did you focus on when designing your product?**
    How it would function, the material to remove the toxic gas (C02) (we need to think about that)
    Need carbon filter, obtain from the car, which has carbon filter
    Use active carbon, filters are relatively cheap
    We should come up with filter that is combination of pm 2.5 filter and toxic gas filter, all in one
13. **What do you think the hardest part of the designing process was for you (She had designed a new, more efficient air filter for Honeywell)?**
    Air flow control, controlling noise and sealing
14. **Did you run into any problems when you were making and designing your product?**
    Mechanical Design was the major problem, what material to use, how to connect all the different components
15. **Should we program something with the product**
    Very good idea, it is necessary and better, possible program an iphone application where it warns you, focus on temperature, because pm 2.5 sensors are expensive
16. **Do you think this will cause problems when the babies are suddenly exposed to bad air**
    No
17. **Do you have any other comments or concerns about out product**
    Mechanical design is very important, need to focus, how to balance the structure, seal it, things like that
18. **Would You Buy this product?**
    Yes if it was cute, cheap and purified air effectively
19. **How is the air circulated in your product?**
    Went in through the sides, up through the top


126
29
PERIC
124
21
PERIC


104
29
PERIC
085
PERIC
chicco

Velcro to secure the cover around the handlebars and around the outside of the stroller.

Cover used to enclose the clean air. Also used to prevent water from going into the stroller. Also makes the stroller look cute.



Handlebars are exposed

Wheels are exposed

This is the fan that we used to push the air through the filter and into the stroller. There are two fans, one on either side and these fans are also replaceable.

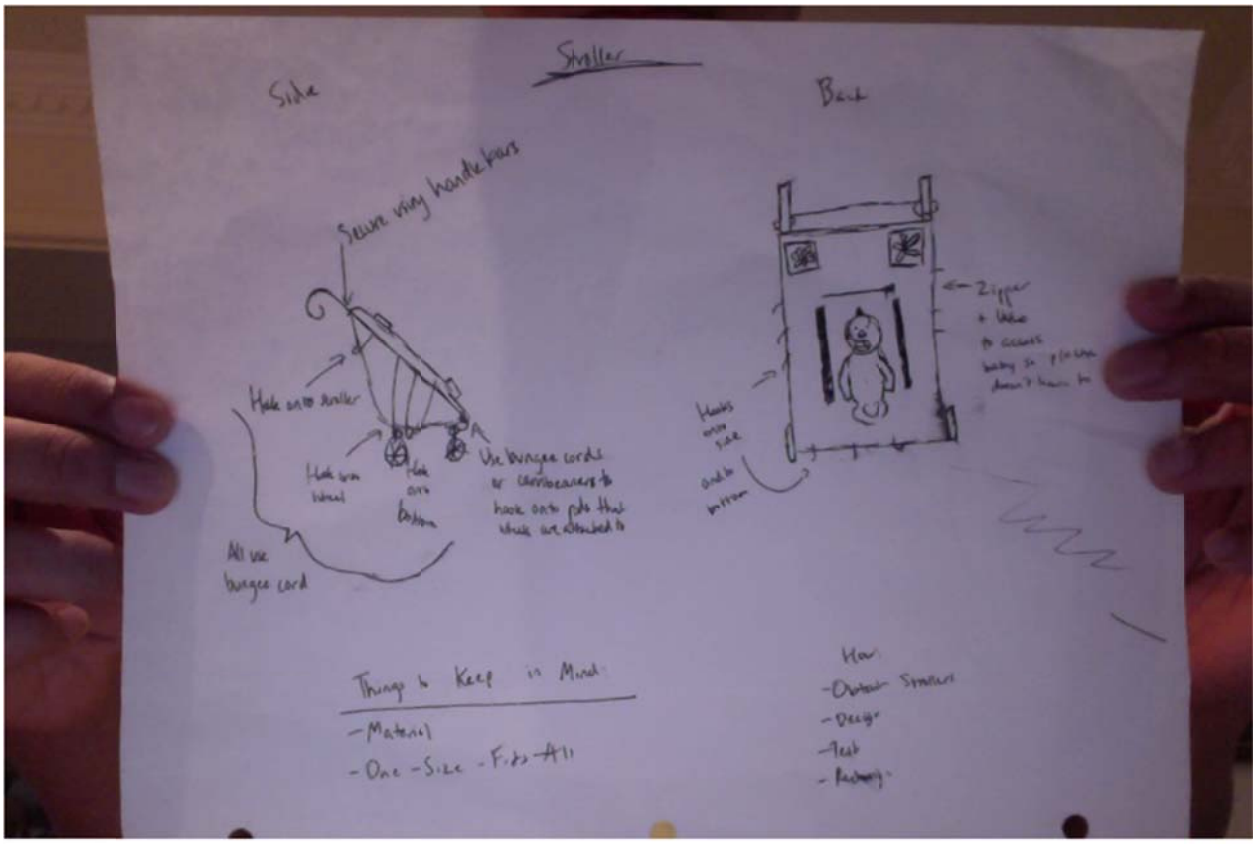
This is the plastic window. It is transparent so that baby can see what is going outside. Also it can open so that you can take the baby in out.

Here is the battery that we use to power the fan. There is also a pocket to store the battery in. That the baby cannot access.

Here is the stroller

Here is the opening and zipper. We can unzip this opening to access the baby.

Here is the filter that we use to filter out the pollutants. there is also another filter on the other side.


Stroller
Side
Back
Sewn way handle bars
Hole onto stroller
Hole onto bottom
Use bungee cords or carabeaners to hook onto pole that stroller are attached to
All use bungee cord
Zipper
Things to Keep in Mind:
- Material
- One - Size - Fits - All
How:
- Outdoor Stroller
- Design
- Seat
- Packing