2.1 Descriptive Title:

IMSA Students' Motivations for using Electricity Generating Bicycles.

2.2 Abstract:

This investigation focused on building a bicycle that IMSA students could use that generates electricity. A 10 question survey was designed to study the motivations of IMSA students to "go Green" and exercise on the bike. Although not every IMSA student was able to utilize the bike, they could nonetheless take the survey recording their motivation for exercising and going green in prior experiences with similar circumstances. The bike was based on a standard bicycle, modified to have its pedals attached directly to a plywood flywheel which in turn powers a generator. The electricity produced is stored in a battery, which connected to an inverter can, charge a phone, iPod, or power anything else plugged into it. Overall, the process of building the bike was challenging in that it had two uses. First it was a device for exercising. But also it was a machine for generating electricity. There was in-fact, two completely separate motivations being studied in just one object. Finally, there are economic advantages to having a dual purpose device like this, with uses beyond the project or even exercise equipment.

2.3 Focusing Question:

What is the impact of an Electricity Generating fitness bike on Illinois Mathematics and Science Academy students, in regards to their motivation for selecting the bike for workout or for their motivation to select a bike for its Green usage on campus?

2.4 Introduction/Rational:

Green technology is a growing part of our society today. The 'Go Green' movement extends worldwide and impacts everything from government, to big companies, to individuals. Green technology is still in the development process. As a source of power generation, it is relatively new and not as advanced as other more mature technologies. But it has garnered much attention and secured its share of development funding. According to Hiroshi Komiyama and Steven Kraines this technology is still in the early stages of development, and needs to be developed more (2008). With the expectation that fossil fuels will run out at the end of the 21st century, renewable energy will be needed to take its place. To this end, it will be important to

progress in the development of green tech (Srinivas, n.d.). To better understand green technology, the pros and cons of it must be analyzed on a small and large scale.

There are few cons to going green, but the reasons have a big impact on the green movement. First of all, the cost of some green technologies is relatively expensive. To cover a home with solar panels would cost a whopping $18,000, and that may or may not be sufficient to provide power to the few residents inside (Devlin, 2012). A less costly step that individuals could do to go green is buy a hybrid car. Since a car is somewhat a necessity for many people, a hybrid car is something that one can use on a daily basis as part of a green lifestyle. The cost of this is an average $4000 more than a comparable non-hybrid car (Romm & Frank, 2006). For someone with a little extra money to spend upfront during the purchase, this could be a practical green decision for many people. But many people are on a strict budget for car buying, so the cheaper the better. According to Jessica Anderson, the payback for some hybrid vs. non-hybrid cars is positive, outweighing the initial extra purchase cost (2011). The expected gasoline price, electricity price, availability of government rebates, and fuel efficiency are all taken into account when deciding if an environmental friendly car is economically beneficial.

These same factors go into consideration whenever any green item is being bought and utilized. Wind farms are being widely constructed, but the economic benefits are relatively meager. While they do help the environment by replacing fossil and other energy sources, their need for constant maintenance and repair makes them a less attractive green initiative to critics. The long pay-back period suggests that there will probably be new and more efficient green technologies with stronger immediate economic benefits before they break even with their initial cost. In addition, most green methods of producing power are not as powerful as other conventional methods. Wind and solar farms are nowhere as powerful as say, coal or nuclear power plants. Also, with a tank of gasoline, one could drive for 400 miles, but for the same car running on same size batteries as the gas tank, range would be a fraction as far.

But overall, going green does have many more advantages than disadvantages. Once again cost comes into play. Like stated earlier there are hybrid cars that are economically beneficial to purchase. There are also green activities that do not require one to spend money. Activities like taking a bike to work, assuming you live close, or combining trips so that to not waste gas on multiple trips to the same location. Not only do these help the environment by cutting down on pollution, but they also save money. There are lots of government-provided

grants and rebates to help with the cost of green activities. Also the green movement parallels the environmental movement, these two group work together to support one another in their efforts.

Green technology is a renewable resource, which means that it can be used over and over again unlike fossil fuels. This is an advantage onto itself. Even if it is not as powerful as other forms of energy, the fact that it is renewable is attractive. Solar panels are not 100% efficient, so they do not utilize all the power that reaches them from the sun, but because green technology like solar panels are being researched, more efficient solar panels will be produced and once popularized they will become very cheap (Salas, 2012). This is another reason to continue to develop and utilize green technology. Finally green technology makes people feel good that they can do something to help the environment. Whether it was riding a bike to work, recycling boxes and cans, or buying a hybrid car, the fact that someone did something positive makes the person feel like they have a hand in saving the planet.

Along with people feeling good themselves about going green, exercise also helps keep people feeling good. Exercise helps increase brain function. Plus, most people feel that exercising gives them a boost of energy. In addition it is physically good for the body. If one exercises, this contributes to overall good health, which also adds to a feeling of well-being. While being at a busy school like IMSA, I have heard the excuse that there is no time in the day to exercise, but the physical exercise helps clear one's brain and makes it easier to concentrate on other things. Overall, it is recommended that everyone gets at least some sort of exercise every day. It might take up some time, but it is worth it to work out.

Cardio respiratory endurance or CRE is exercise which you sustain over any long period of time and gets your heart beating faster than usual for a sustained time. A typical CRE workout is something like running or biking, where the activity lasts for a while. CRE gets the blood flowing through your whole body, and is a good example of exercise that improves your mind, body, and overall mood. It is also a very common type of exercising for people to do each day. When at the gym, most people are biking, running, rowing, or using the elliptical machine. There is also the muscle strength form of working out, which uses weights and does activities for a short burst of time and requiring a burst of energy, not sustained activity. When at a gym, the muscle strength activities are popular, but most people stick to the CRE machines.

Exercising and going green seem like two totally different activities, but they are both very good to do. I wanted to combine these two activities into one activity, and building an

energy generating bike seemed like the perfect way to combine them. CRE is sustained over a long time, making it easier to generate electricity compared to muscle strength machines. It is like killing two birds with one stone. An energy generating bike would satisfy the daily beneficial exercise that people should get and the growing "go green" movement. Right now these activities are individually popular, so finding a successful way to combine the two would seem attractive. People are motivated to go green and motivated to exercise, and I thought that it would be interesting to study whether an energy generating bike would increase both of those motivations.

2.5 Materials and Methods:

To test this, I needed to create two things. First, an actual bike that would generate electricity when peddled, and second, a way of testing the motivation of IMSA students to use this bike. There are two different main types of bikes that are made to generate electricity, direct driven and belt driven. The direct driven bikes have the generator actually touch the spinning back wheel of the bike, and from that the generator turns, creating electricity. The belt driven bike is where the back tire is modified so that a belt runs around it which in turn spins the generator. I chose to go with the direct method for building an energy generating bike. I did this because this required fewer parts, so would be easier to build refine. In addition the direct method does not need a special modified back tire to run a belt around. I used a children's bike with no tires on it for the frame. The only moving parts that I used were the pedals. From there I cut out a large plywood flywheel which mounted directly to the pedals; no bike chains were used to spin the wheel. I attached a board perpendicular to the front pegs where the front tire would usually go, so that the bike is stabilized. Onto the main diagonal frame piece of the bike I attached a long metal pipe which extended far past the end of the bike. This served to support the back of the bike, and provide a place to mount the generator on. Behind the bike on the long metal bar, I attached a Mando 0017-0009-0841 alternator. On this generator, there was no good way to engage the shaft to the bike flywheel, so I fitted a scooter wheel to the generator shaft. This rubber wheel provided a great friction connection between the plywood wheel and the shaft of the generator.

That was as far as I got in terms of building the actual bike. I never got to the final step where I would attach a battery to the generator due to complication with receiving parts.

However, if my parts did come in, I would have attached a 12 volt AC to DC charge controller, to change up the battery. On the wire from the charge controller to the battery I would have attached a diode so the electricity from the battery does not go the other way and discharge the battery. On the battery, I would attach a power inverter so that the battery could be used as an AC wall socket. This would give the user the opportunity to power anything they wanted, like their iPod, phone, or computer.

The bike was never completed, so students never got the opportunity to utilize an energy generating bike, but they could still answer questions about their motivations to go green and perform CRE workouts. To do this, I created a ten question survey which asked different questions about motivations. The ten questions are found in table 1 in the appendix. The questions were on a rating scale from 1 to 10, where 1 is the least and 10 is the most. The goal of the survey was to compare the motivations to go green and perform CRE workouts in general, and then compare it with the motivations with the addition of an energy generating bike. I did not have a bike to go along with the survey, so I put special emphasis on the wording of the question so that I could get good results. I then distributed the survey by sending a mass email out to all the IMSA students.

With the survey results I ran a Wilcoxon Paired-Samples Test which analyzes ordinal data. I ran the test with question 1 and question 6 to compare the motivations to perform CRE workouts without and with the bike, and with question 2 and question 7 to compare the motivations to go green without and with the bike. I got a T+ and T- value for both tests and used a table of the critical values of the Wilcoxon T distribution to get an approximation for the two tailed p value.

2.6 Results/Body:

With the data from question 1 and 6, I ran a Wilcoxon Paired-Samples Test and got a T+ 24 of blank and a T- value of 23. From that I used a table of the critical values of the Wilcoxon T distribution to find an approximate p value greater than .5 (n=10, T+=24, T-=23, p>.5). With the data from question 2 and 7, I ran the same test and got a T+ value of 14.5 and a T- 13.5 of blank. From that I used the Wilcoxon critical values table to find an approximate p value greater than .5 (n=10, T+=14.5, T-=13.5, .1<p<.2). These two pairs of samples, questions 1 and 6 and question

2 and 7, are graphed in Graph 1 and Graph 2, respectively. The raw data from the survey can be seen in Table 1.

2.7 Conclusion:

My null hypothesis for the test was that with the addition of an energy generating bike, the motivation of IMSA students to go green and perform CRE exercises would not change. Because both of my p values were greater than .05, I failed to reject my null hypothesis. This means that with the data I have now, I could not conclude that an energy generating bike had any effect on motivations to go green and perform CRE exercises. Going back to the focusing question, I can answer that an energy generating bike has no impact on the motivations of IMSA students to go green or perform CRE workouts.

2.8 Discussion:

My results were unexpected. I thought that the addition of an energy generating bike would increase the motivation to go green and perform CRE. Bill Ryan from the University of Wisconsin Extended says that the amount of people who care about the environment has increased from 2004 to 2006, and I would think that this trend would continue. Because of that, I thought people would care even more about with the environment with the addition of an energy generating bike, so their motivations to go green would increase (2006). However this was not the case. There was no change in the motivations with and without the bike. These results might have been skewed because there was no energy generating bike for the IMSA students to utilize on campus, and their idea of one might have not been completely as I described it. Also, they could have seen disadvantages to an energy generating workout bike, including the possibility that it does not feel the same as a regular bike, or other stationary bikes. Another explanation for these results may be that the people who were not motivated to perform CRE or go green would not actually increase their motivation because there was so little motivation to do either of these activities in the first place. To test for this, I would need data from each individual, and then just compare the more motivated people, to see if they had an increase, and compare the non-motivated people to see if there was no change in their motivations.

Although the bike had no effect on motivations, it still did the job of combining green technology with exercise. An energy generating bike is an inexpensive way to go green, and

therefore there might be some economic advantage to these bikes. That would be a future test to do, the economic benefits of energy generating bikes. Also, even if one of these bikes works, the bike can still be modified to produce more energy. This is just like how solar panels are being modified to capture a greater fraction of the power that the sun in emitting.

2.9 Inquiry Process:

The inquiry process provided me a better way to learn. It made me actually do research into my topic, and find out about going green and CRE exercising. Then from information that I gathered, I formulated my own ideas about the topic. Overall, this took more time to do, because the important ideas were not somewhere in a textbook for me to look up. However, what I did learn, I will not forget. The inquiry process is not like the end of a unit, where after the test is done, then the information can just leave your brain. Rather, the inquiry process builds the information into you, so that you will never forget what you learned. Plus, it was on a topic that I liked, so doing anything for SIR was not tedious. I now have a better understanding of the phrase, find a job you like and you add five days to every week, except in this case I added a Wednesday to every week.

I did not completely finish what I set out to do. I had plans for a better looking bike that would become part of the IMSA fitness center. However I was not able to actually build a working energy generating bike. The only problem was with receiving parts. It would always seem that they were late, lost or never ordered. This taught me something not about learning, but about working through people with money and control. I had no money to use on this project, so I could order the parts myself. Then when others ordered them for me, problems always arose. I now know that if I need something done, like ordering parts, then I should either give it ten times more time to arrive, or get the funds together to do it myself.

The problem with the bike parts changed my path drastically. Initially I wanted to order parts to make a belt driven energy generating bike. I had permission to use a bike in the fitness center and retrofit a generator and electronics on it. But then that just turned out to be too difficult, so we ordered a pre-made bike stand that would hold up the back tire of any bike and turn it into an energy generating bike. That part never came in, so then I was left with a half built bike from someone else. I tried to get this one working, but after a certain point I needed more parts, which had problems being ordered. I just had to go with the flow and see where the project

would take me, not where I was trying to steer the project. In conclusion, the inquiry process has a few disadvantages, but the freedom to learn and the ability to focus on a topic you like greatly outweighs them.

2.3 Literature Cited:

Komiyama, H., Kraines, S. (2008). *Introduction of Renewable Energy*. Retrieved from http://www.springerlink.com/content/j37xv5p721337778/.

Srinivas, H. (n.d.). Going with the Wind: Wind Energy Potentials. Retrieved from http://www.gdrc.org/uem/energy/wind-intro.html.

Devlin, L. (2012, April 20). How Much Does it Cost to Install Solar on an Average US House? Retrieved from http://solarpowerauthority.com/how-much-does-it-cost-to-install-solar-on-an-average-us-house/.

Romm, J. J., Frank, A. A. (2006, April). Hybrid Vehicles Gain Traction. *Scientific American, 294*(4), 72-79.

Anderson, J. (2011, September 1). Green Cars Make Cents. *Kiplinger's Personal Finance, 65*(9), 86.

Salas, D. (2012, February 21). Researchers to make low-cost solar panels. Retrieved from http://www.wildcat.arizona.edu/index.php/article/2012/02/researchers_to_make_lowcost_solar_panels.

Ryan, B. (2006, November). Green Consumers: A Growing Market for Many Local Businesses. *Let's Talk Business, 123*. Retrieved from http://www.uwex.edu/ces/cced/downtowns/ltb/lets/LTB1106.pdf.

2.4 Bibliography:

Anonymous. "On the Need for Physical Fitness." *The Atlantic Monthly*. Annals of American History, n.d. Web. 30 Nov. 2011.

Aurelio J.M. (2010, June 19). Jail Guard's Invention Saves on Power. *Inquire.net*. Retrieved from http://newsinfo.inquirer.net/inquirerheadlines/metro/view/20100619-276504/Jail-guards-invention-saves-on-power.

Bdwhaley. (n.d.). 440 Watt Regulated Pedal Power Bicycle Generator for iPod, Cell Phone, Portable TV or DVD player. Retrieved from http://www.instructables.com/id/Bicyle-Power-for-Your-Television,-Laptop,-or-Cell-/.

Butcher, D. (2006, June 1). Pedal Powered Generator. *Altenergymag.com*. Retrieved from http://www.altenergymag.com/emagazine.php?issue_number=06.06.01&article=pedalpower.

Butcher D. (n.d.). Pedal Powered Generator - Electricity From Exercise. Retrieved from http://www.los-gatos.ca.us/davidbu/pedgen.html.

Convergence Technologies, Inc. (n.d.). The Pedal-A-Watt Stationary Bike Power Generator. Retrieved from http://www.econvergence.net/electro.htm.

Dunlop, J. P. (1997, January 15). Batteries and Charge Control in Stand-Alone Photovoltaic Systems: Fundamentals and Application. Retrieved from http://www.localenergy.org/pdfs/Document%20Library/Fundamentals%20of%20batteries%20and%20charge%20control.pdf.

Electric Cars and Alternative Options. (2003, June 2). Retrieved from http://cr.middlebury.edu/es/altenergylife/electric_car_page.htm.

Gibson, T. (2011, July). These Exercise Machines Turn Your Sweat Into Electricity. Retrieved from http://spectrum.ieee.org/green-tech/conservation/these-exercise-machines-turn-your-sweat-into-electricity/0.

Holmes, K.J., Papay L. (2011, July 26). Prospects for Electricity from Renewable Resources in the United States. *Journal of Renewable and Sustainable Energy, 3, (14 pages)*. doi: 10.1063/1.3613947.

Komiyama, H., Kraines, S. (2008). *Introduction of Renewable Energy*. Retrieved from http://www.springerlink.com/content/j37xv5p721337778/.

MNS Power. (n.d.). Free Video Plans/Instructions For do it Yourselfers. Retrieved from http://www.pedalpowergenerator.com/index.html#FREE.

MNS Power. (n.d.). Gen-a-rider Stationary Exercise Bike Generator. http://pedalpowergenerator.com/buy-bicycle-generator-assembled-pm-motor-pedal-power.htm#STATIONARY.

Morton, R. (2010, November 3). Pedal Power Pumps Up Pupils. *Greater Media Newspapers*. Retrieved from http://nt.gmnews.com/news/2010-11-03/Schools/Pedal_power_pumps_up_pupils.html.

Renewable Energy New Brunswick Ltd. (n.d.). Charge Controllers Information. Retrieved from http://www.renewcanada.com/charge_controllers.html.

Stanevich, K. (2012). *SIR Abstract*. Unpublished manuscript, Illinois Math and Science Academy, Aurora, IL.

Stanevich, K. (2012). *SIR Progress Report*. Unpublished manuscript, Illinois Math and Science Academy, Aurora, IL.

Stanevich, K. (2011). *SIR Project Proposal*. Unpublished manuscript, Illinois Math and Science Academy, Aurora, IL.

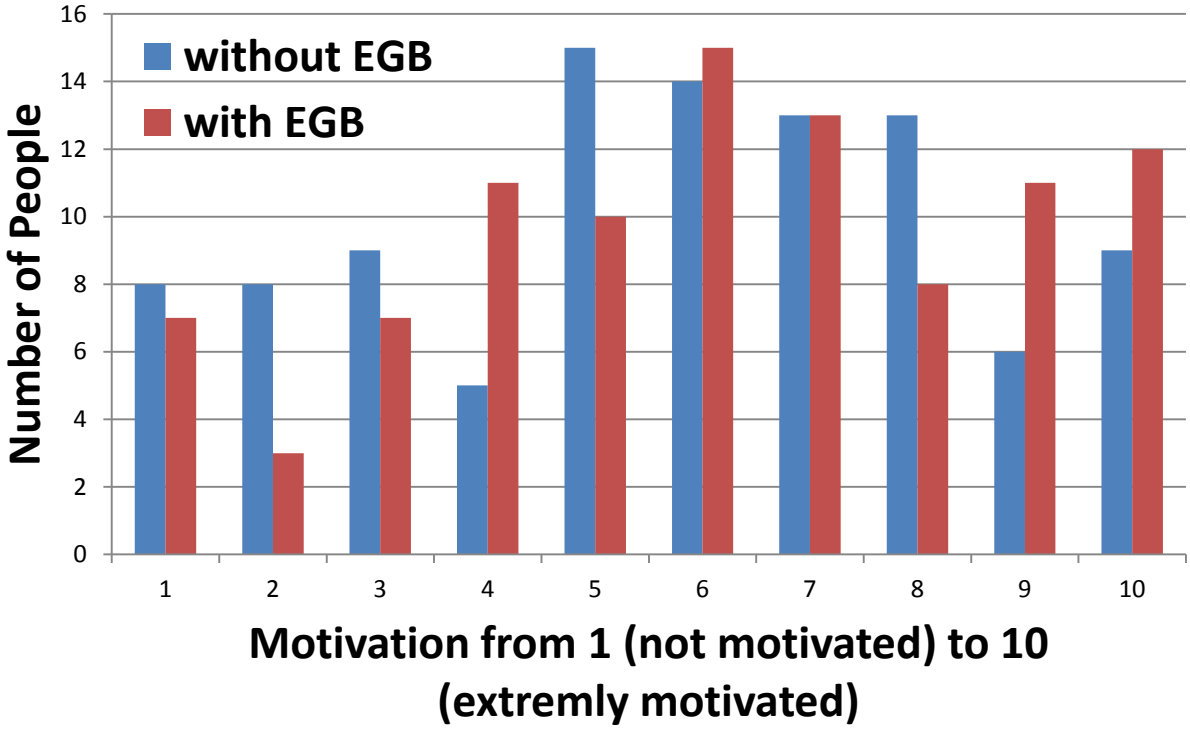
Windstream Power LLC. (n.d.). Human Power Generator Series: Bike Power Generator. Retrieved from http://www.windstreampower.com/Bike_Power_Generator.php.

Woodbank Communications Ltd. (n.d.). Battery Chargers and Charging Methods. Retrieved from http://www.mpoweruk.com/chargers.htm.

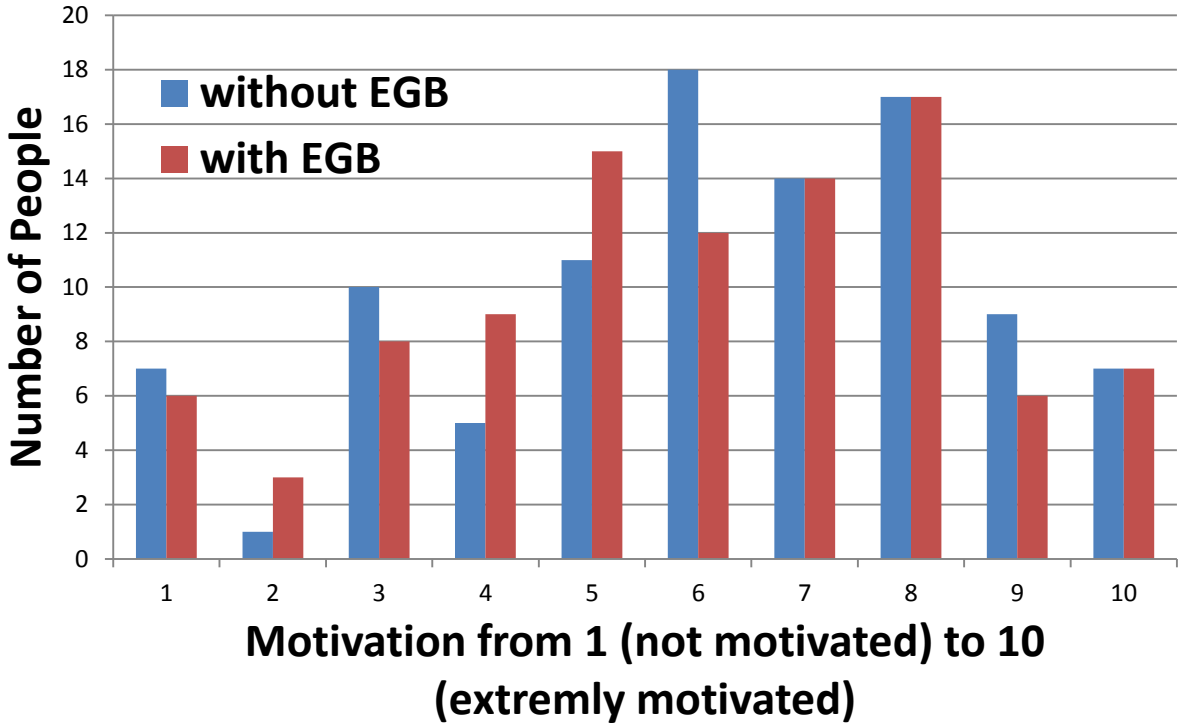
2.12 Acknowledgements:

I would like to thank Mr. Gentzler for being my advisor and helping with the majority of the project and especially with any part of the project that involved aspects of fitness. In addition I would like to thank Mr. Lawrence for helping with and engineering aspects of building the bike and ordering all the parts that I needed. I thank Mr. Urbanski for helping me actually build parts of the bike and taking me through the steps to think like an engineer. Finally, I would like to thank the SIR staff and all the students who toke my survey, because without them I would not have completed this project.

2.13 Appendix:



Graph 1. Motivation to perform CRE workouts. This is the results from the survey comparing IMSA student's motivations to perform CRE workouts with and without an energy generating bike available. There is no statistically significant difference. (n=10, T+=24, T-=23, p>.5)



Graph 2. Motivation to 'go green'. This is the results from the survey comparing IMSA student's motivations to 'go green' with and without an energy generating bike available. There is no statistically significant difference. (n=10, T+=14.5, T-=13.5, .1<p<.2)

How motivated are you perform Cardio Respiratory Endurance (CRE) workouts?									
8	**8**	**9**	**5**	**15**	**14**	**13**	**13**	**6**	**9**
How motivated are you to be "Green" in everyday life?									
7	**1**	**10**	**5**	**11**	**18**	**14**	**17**	**9**	**7**
How often do you work out using CRE Machines?									
12	**15**	**19**	**10**	**5**	**11**	**12**	**8**	**4**	**2**
Given opportunities daily to go green, how often do you chose these options?									
0	**1**	**7**	**9**	**12**	**10**	**15**	**24**	**13**	**8**
If there was an energy generating bike for your use, how often would you use it?									
5	**4**	**8**	**13**	**15**	**15**	**11**	**12**	**6**	**9**
How motivated would you be to perform CRE workouts if you could utilize an energy generating bike?									
7	**3**	**7**	**11**	**10**	**15**	**13**	**8**	**11**	**12**
How motivated would you be to go green if an energy generating bike existed in the IMSA fitness center?									
6	**3**	**8**	**9**	**15**	**12**	**14**	**17**	**6**	**7**
How often would you use this bike if it could charge your phone, computer, iPod, and other items for your daily use and convenience?									
5	**3**	**4**	**6**	**10**	**13**	**11**	**19**	**8**	**19**
How often would you use this bike if it was used to power the needs of IMSA campus?									
5	**4**	**2**	**7**	**10**	**13**	**18**	**18**	**9**	**12**
How important is the similarity of this bike compared to the non-energy producing bikes in reference to the feel of riding?									
7	**1**	**4**	**7**	**14**	**15**	**8**	**19**	**13**	**11**

Table 1. Table of IMSA students survey results. Question 1 was compared to question 6 and question 2 was compared to question 7 to test if the addition of an energy generating bike had any impact on the motivations of the students.