Analyzing habits, willingness, effectiveness, and costs of current household energy-saving activities.

Cheng Ian Hoi, Christopher Cheng, Selina Ho, Stanley Yuen

University of British Columbia

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Team Energy Efficiency

Christopher Cheng, Selina Ho, Cheng Ian Hoi, Stanley Yuen

Executive Summary

For our team's energy conservation study, we examined four attributes related to energy conservation: Vancouver residents' current beliefs about effective energy saving practices at home, conservation actions currently executed by residents, additional actions or activities they would be willing to adopt, and perceptions regarding costs of certain activities. Ultimately, our research question was: *What do Vancouver residents believe are the most effective energy conservation practices at home? What actions are they currently doing and what would they be willing to adopt?*

For our study, we conducted a survey that asked participants ten common energy conservation activities (such as turning off the light) and measured their current habits, perceived effectiveness, willingness to implement and perceived cost of engaging in the activity.

The results from our study show that majority of Vancouver residents aim to run full loads of laundry. Additionally, it seems that most Vancouverites are unwilling to install energy monitoring devices, despite the long-run cost savings. Lastly in terms of costs affecting the other factors, we had inconclusive results, but we did conclude that cost and willingness to implement conservation practices are not independent.

This report will outline our study, explain our analysis and walk through our recommendations.

Intro
Our team is called "Energy Efficiency" and the members of our team include Christopher Cheng, Selina Ho, Cheng Ian Hoi and Stanley Yuen. The title of our research project is "analyzing habits, willingness, effectiveness, and costs of current household energy-saving activities".

Research Question and Hypotheses
Our research question is: "*What do Vancouver residents believe are the most effective energy conservation practices at home? What actions are they currently doing and what would they be willing to adopt*?"

We hypothesized that the energy-saving activity that majority of our respondents would currently be engaged in is turning off their lights when leaving a room. Additionally, we hypothesized that respondents would be least engaged with unplugging unused electronic devices. We also thought households would be less willing to engage in activities that are perceived to be more expensive, such as installing energy monitoring devices. Finally, we hypothesized that activities perceived to be the cheapest would also be perceived as the most effective in saving energy.

Participants
142 participants answered our survey and the overview of demographics is in Appendix B.

Conditions
We identified ten common energy conservation techniques that our team compiled through brainstorming, as well as research from BC Hydro and FortisBC's energy saving tips. The finalized list of the ten conservation practices is listed in Appendix A.

Measures
In order to compare each of the ten energy conservation activities, we determined that each activity had four different measurement factors. These four measurements are as follows: "Do you currently engage in this activity?", "How effective do you believe this activity is at conserving energy?", "How willing would you participate in this activity?" and "How expensive do you perceive this activity to be" (Appendix C).

Procedure
The most effective method to gather results from our research participants was through a self-report questionnaire. Our self-report questionnaire contained basic information such as age, gender, housing location, and income to segment respondents based on each factor. Then, we asked each participant to consider the ten previously mentioned energy conservation activities. For each of the ten activities, participants answered four measures, which examined current engagement, willingness to adopt, perceived effectiveness, and perceived costs.
To gather a representative sample, we utilized our personal networks of university peers as well as family, friends and neighbours. Additionally, to ensure that we had an adequate representation of Vancouver residents throughout the area and a variety of participant demographics, our team approached various individuals to complete our survey on iPads at Pacific Centre, Metrotown,

Richmond Centre and Oakridge Center. Being at these malls and scouting out individuals who were waiting for other people, or their food allowed us to get a representative sample population.

Once we surpassed our target of 120 respondents, we removed falsified data to ensure validity in our results. Then, we aggregated our data and ran analyses including two-way ANOVAs and correlational tests to reject or accept our four hypotheses.

Results

From our 142 respondents, we took an average score and discovered that the activity that was most currently adopted was *running full loads of laundry* (Scoring 8.7 out of 10), and the activity least currently adopted was *installing energy monitoring devices* (2.0). Moreover, it was perceived by individuals that the most expensive activity was *switching to energy efficient appliances* (7.4) whereas the least expensive was to *hang dry laundry* (2.9). The full chart of our average scores to each 10 activity and the four questions can be found in Appendix D.

After running a 10x4 two-way ANOVA with the listed activities and results, we found that there was a statistically significant difference in the responses to each activity [$P < 0.01$], between the questions [$P < 0.01$], and in the interactions between the two [$f(3,27) = 34.43$, $P < 0.01$] (Appendix E). However, we needed to run additional analyses to truly answer our hypotheses, so we ran Tukey's post-hoc and a line of best fit between two questions at a time to determine any correlations. Our first two hypotheses were rejected, which was answered by simply looking at our results. As previously stated, the activity most people currently engaged in was not *turning off the lights*, but rather *running full loads of laundry*; and the least currently engaged activity was not *unplugging devices*, but instead *installing energy monitors*.

Our third hypothesis was that activities perceived to be the more expensive were also less willing to be adopted. In order to analyze this, we looked at the between-subject effects and found that between these two factors, the significance between the mean differences were 0.769 (Appendix F), which was not enough to reject the null hypothesis. This means that we cannot assume on a 95% confidence level that the two factors are independent of one another. However, to confirm these results, we plotted all the results on a graph to run a line of best fit, and found a very weak correlation ($R^2 = 0.0189$) between perceived cost of activity and the willingness to adopt it (Appendix H, iii). Therefore, we rejected our third hypothesis as well.

Our last hypothesis examined if activities that were perceived to be effective would also be perceived to be the less costly. We ran the same tests as we had done to test hypothesis three, and found that the significance in the difference between the means was 0.822 so once again, we could not reject our null hypothesis. When we graphed a line of best fit, we found no correlation between the two factors ($R^2 = 0.0003$) (Appendix H, ii), so we also rejected our last hypothesis.

Discussions

Although we rejected all four of our hypotheses, there were other takeaways that we derived from the results. Specifically, we learned which energy-saving activities were most and least common, as well as the perception of respondents in regards to these activities. We also compared the perceptions of cost and effectiveness to uncover any existing misunderstandings or false beliefs.

Unsurprisingly, the questions that scored the highest on correlation were between perceived effectiveness and currently engaged ($R^2 = 0.2076$) (Appendix H, iv) and willingness to adopt and perceived effectiveness ($R^2 = 0.2404$) (Appendix H, i). This shows that the activities that participants believe to be the most effective are also the activities that they are currently doing or are most willing to adopt. This finding has significant implications, as it the perceived effectiveness of an activity may not actually be the most effective at conserving energy. For example, the activity of unplugging unused devices from outlets was ranked as the second least effective activity out of the ten. However, when looking at BC Hydro's list of energy saving tips, unplugging unused devices saved the average household $50 per year, while other activities that were ranked higher in our survey such as running full loads of laundry or washing in cold water saved only $30 and $27 annually respectively (BC Hydro, 2012).

Furthermore, there is an issue of energy conservation practices that are perceived to be expensive. With additional research and consultation with secondary sources, such as BC Hydro's factsheet analysis (BC Hydro, 2010), it is revealed that a traditional incandescent light bulb costs $30 more to power over 10,000 hours compared to a CFL light bulb. A CFL light bulb also lasts 10 times longer than a traditional incandescent light bulb. However, an incandescent costs approximately $1.00 whereas CFLs costs $2.50 or more. This means that initial costs of incandescent light bulbs may be less costly initially, but the CFL light bulbs will provide cost savings in energy usage as well as longevity. It is also important to note that we do not fully understand if our respondents only considered the upfront cost for energy conservation practices, or the total lifetime cost when answering our questionnaire.

Ultimately, we developed several implications from our study. We can infer from our data that respondents seem to only consider initial cost of implementing activities and potentially ignore the cost savings that can arise as a result. For example, switching to CFL and LED lights are expensive than incandescent light bulbs, but the electricity costs saved will offset the initial cost in long run. We also learned that the perceived effectiveness is correlated with current behaviours as well as willingness to implement these behaviours. However, these perceptions may not be accurate, as we saw from comparing with actual data on behalf of BC Hydro and FortisBC.

Limitations:

Some limitations to our survey include that our energy conservation tactics were not open-ended, as participants could only rate their opinions on 10 close-ended conservation methods. This meant that the survey was limited to the activities proposed by our team and respondents could not list their own energy conservation techniques. However, limiting the conservation tactics allowed us to control the data and limit our analysis. Ultimately, we recognize that there are other methods to save energy, besides the 10 that were listed in the survey.

Additionally, a handful of participants may have been misunderstood the measure "how expensive do you perceive this activity to be", as we asked them to rank the perceived cots associated with each conservation activity on a Likert scale of 1 to 10. A few individuals assigned a score of 1 instead of 10 for the activities perceived to be the most expensive. We did

explicitly state what each end of the scale stood for this in our survey, but perhaps these individuals didn't read our explanation, or properly understand it.

Lastly, we discovered framing effect in our survey, specifically when we asked participants about the four measures. Particularly, we asked "do you currently **engage** in this activity", "how **effective** do you believe this activity is at conserving energy" and "how **willing** would you participate in this activity". The bolded words highlight words associated with a gain, which could have biased our respondents. Similarly, when we asked participants "how **expensive** do you perceive this activity to be", the word expensive is associated with a loss, which could have impacted respondents. Instead, we should have phrased the questions to be "does this activity conserve energy", "would you participate in this activity", "how costly is this activity", etc.

Recommendations

Firstly, we recommend that Vancouver residents be given more education of energy saving strategies and activities. Specifically, Vancouverites need to be aware that there are many ways to conserve energy and that these energy-saving activities can add up to significant cost-savings.

Additionally, it is important to reinforce to Vancouver residents that implementing energy-saving activities does not have to be expensive. For instance, using a dryer is more costly than hang-drying the clothes. This is something to point out to Vancouverites, as energy conservation can also help save money while being environmentally friendly.

In terms of monetary motivations behind energy conservation, our study had inconclusive results. The data shows that cost and willingness to implement conservation practices are not independent, but through our analysis we could not find a strong correlation between the two either. Therefore, more research is needed on cost as a motivation factor to fully understand willingness to adopt certain activities as a function of implementation costs. Additionally, we discovered it is also important to distinguish between the cost of implementing an energy conversation practice (eg: buying an energy saving monitor device) and the cost savings that can occur (eg: lower electricity bills).

To combine this with earlier results showing the difference between actual effectiveness of certain activities compared to the perceived effectiveness, we recommend that this information is more clearly communicated to consumers through cost-savings. By presenting the information in an understandable way, we hope to change the mindset and help the public better their knowledge of energy conservation strategies that actually work. As seen with the correlation between perceived effectiveness and willingness to adopt, we are optimistic that this will change their willingness to adopt the best energy-saving activities.

Lastly, we recognize that there are other methods to conserve energy that may not have been included in the 10 common energy conservation conditions that was utilized in this study. Although we chose the 10 most common conservation practices and tried to cover a wide range of energy conservation techniques, we recognize that research on other energy conservation activities should be examined in the future. This will allow a more complete and accurate recommendation regarding energy conservation.

Appendices

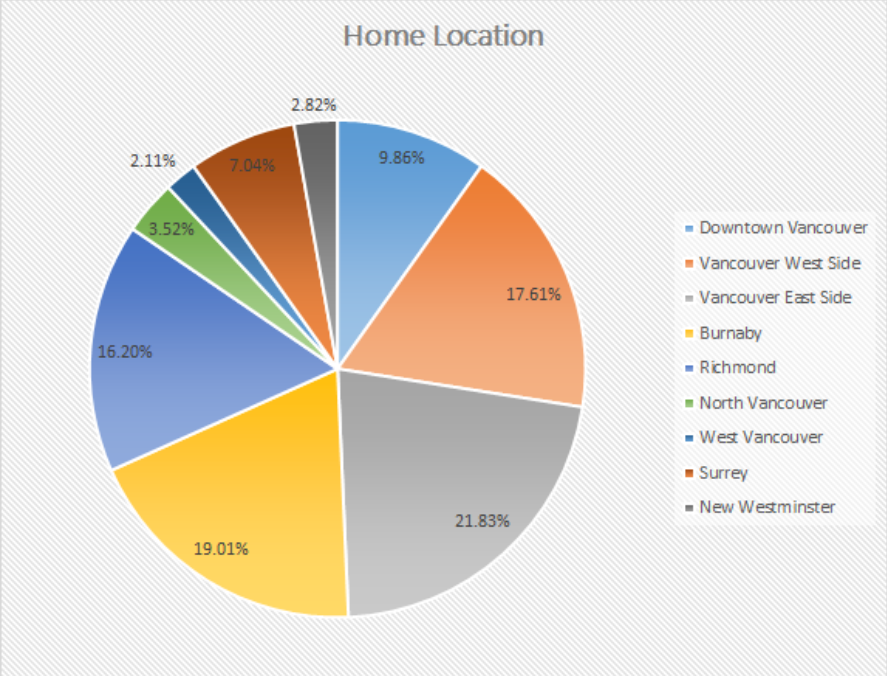
Appendix A: List of the 10 Common Energy-Saving Activities

1. Turning off lights when leaving room
2. Turning off heating/thermostat when leaving house
3. Unplugging unused electronic devices from outlets
4. Switching to CFL or LED light bulbs
5. Switching to energy efficient appliances
6. Hang drying your laundry
7. Installing energy monitoring devices
8. Running full loads of laundry
9. Opening windows instead of air conditioning
10. Washing laundry using cold water

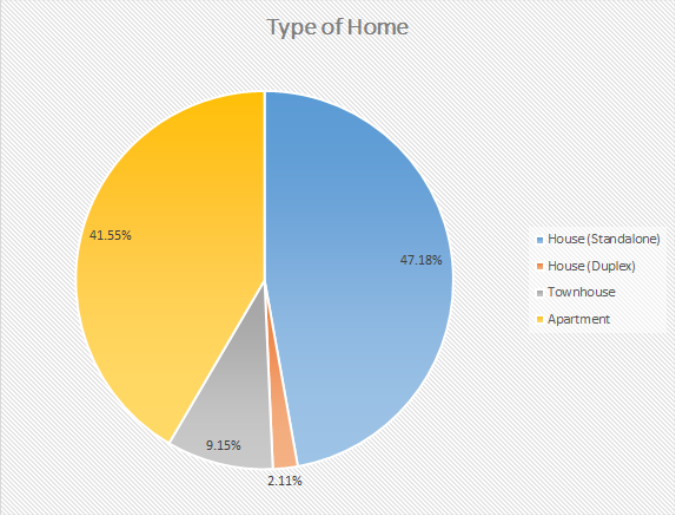
** This is also the order of the activities seen in the graphs in Appendix G*

Appendix B: Participant Information

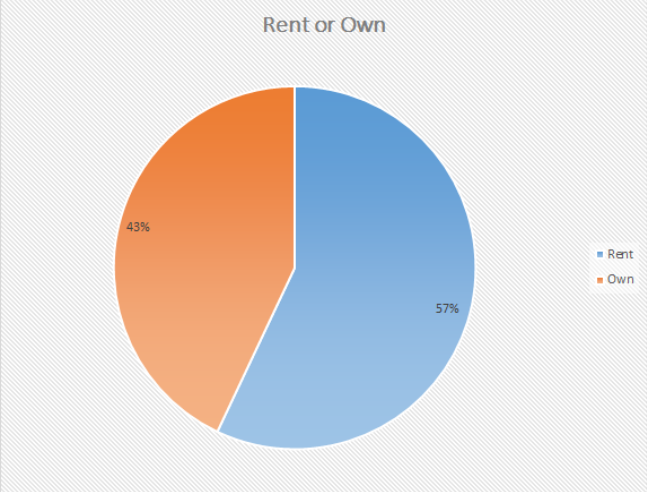
i. Home Location



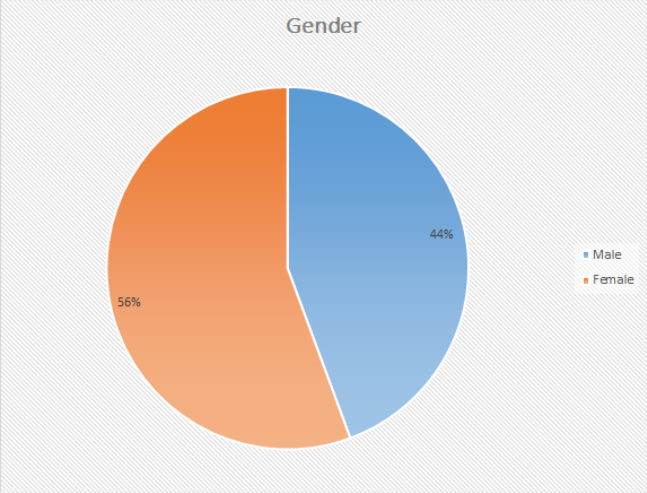
ii. Type of Home



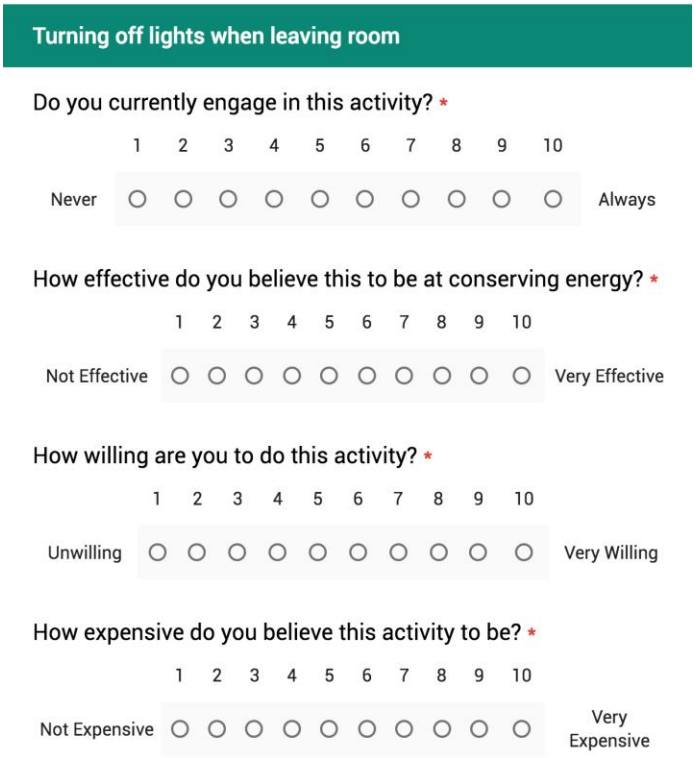
iii. Rent or Own



iv. Gender



Appendix C: Sample Survey Question



Appendix D: Primary Results (Mean Scores)

Activity	Average Currently	Effective	Willing	Expensive	Total
Turning Off Lights When Leaving Room	8.3	8.2	9.2	3.3	8.1
Turn off heating/thermostat when leaving house	5.1	8.0	6.6	4.3	6.3
Unplugging unused electronic devices from outlets	3.8	5.6	5.0	3.3	5.3
Switching to CFL or LED Lightbulbs	6.5	8.2	7.3	5.5	6.6
Switching to energy efficient appliances	5.2	7.8	6.1	7.4	5.4
Hang drying your laundry	5.3	7.4	5.5	2.9	6.3
Installing energy monitoring devices	2.0	5.5	4.3	6.4	3.8
Running full loads of laundry	8.7	7.5	8.6	3.5	7.9
Opening windows instead of air conditioning	8.5	8.7	8.2	3.2	8.1
Washing laundry using cold water	6.8	6.9	7.3	3.3	7.0
Maximum	8.7	8.7	9.2	7.4	8.1
Minimum	2.0	5.5	4.3	2.9	3.8

Appendix E: Two-Way ANOVA Results

TWO-WAY ANOVA Results						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample	3643.0336	9	404.7815	71.034098	6.042E-121	1.88251
Columns	4773.8386	3	1591.28	279.24968	8.893E-163	2.6074
Interaction	5296.5808	27	196.1697	34.425325	3.56E-157	1.48883
Within	20286.344	3560	5.698411			
Total	33999.798	3599				

Appendix F: Analysis Results (Between-Subject Effects)

Tests of Between-Subjects Effects

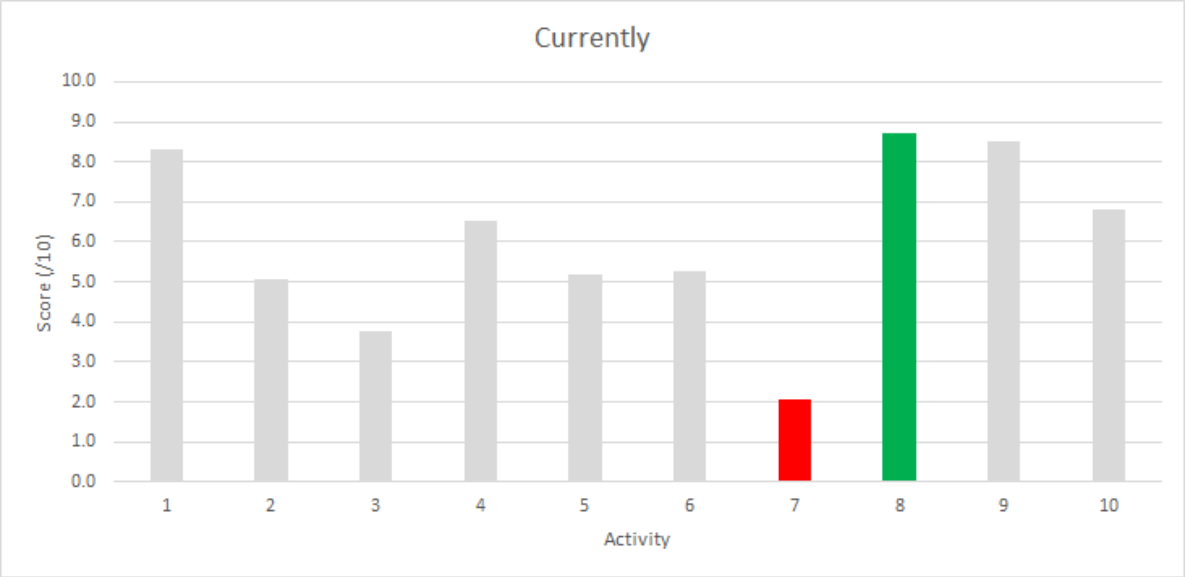
Dependent Variable: Activity

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	5267.340[a]	653	8.066	.920	.792	.709
Intercept	7882.385	1	7882.385	898.690	.000	.785
Currently	130.726	9	14.525	1.656	.100	.057
Effective	124.164	9	13.796	1.573	.124	.054
Willing	62.672	9	6.964	.794	.622	.028
Expensive	25.356	9	2.817	.321	.968	.012
Currently * Effective	394.845	34	11.613	1.324	.118	.155
Currently * Willing	233.107	32	7.285	.831	.730	.098
Currently * Expensive	332.719	47	7.079	.807	.809	.134
Effective * Willing	256.638	36	7.129	.813	.769	.106
Effective * Expensive	383.534	54	7.102	.810	.822	.151
Willing * Expensive	353.339	48	7.361	.839	.764	.141
Currently * Effective * Willing	13.191	3	4.397	.501	.682	.006
Currently * Effective * Expensive	70.303	8	8.788	1.002	.435	.032
Currently * Willing * Expensive	15.902	5	3.180	.363	.874	.007
Effective * Willing * Expensive	4.654	1	4.654	.531	.467	.002
Currently * Effective * Willing * Expensive	.000	0	.	.	.	.000
Error	2157.660	246	8.771			
Total	34650.000	900				
Corrected Total	7425.000	899				

a. R Squared = .709 (Adjusted R Squared = -.062)

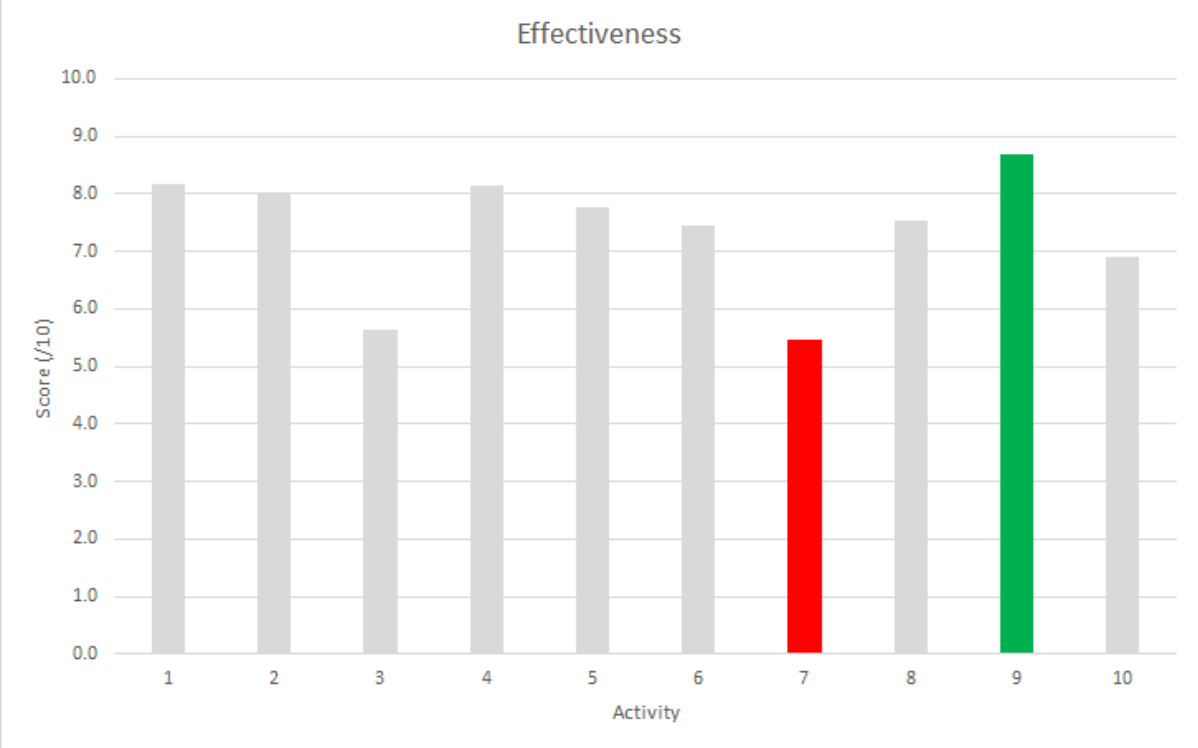
Appendix G: Analysis of Results (Graphed)

i. Current Engagement for Each Activity



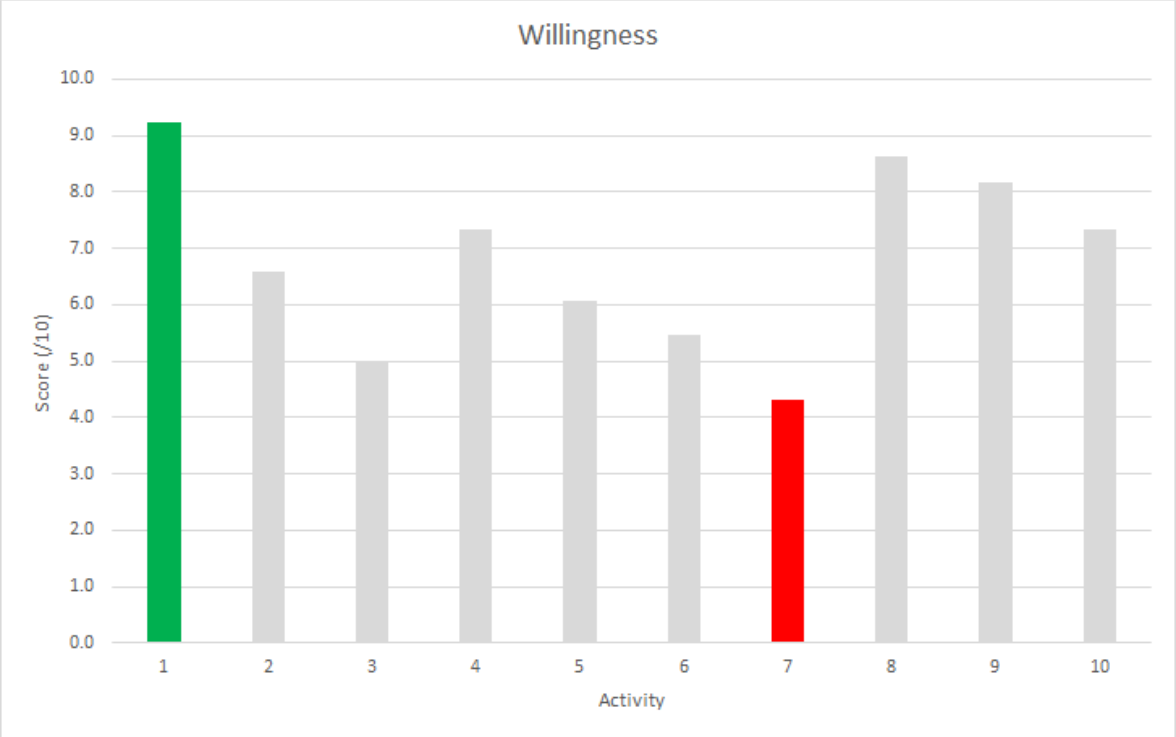
(See Appendix A for legend for Activities)

ii. Perceived Effectiveness for Each Activity



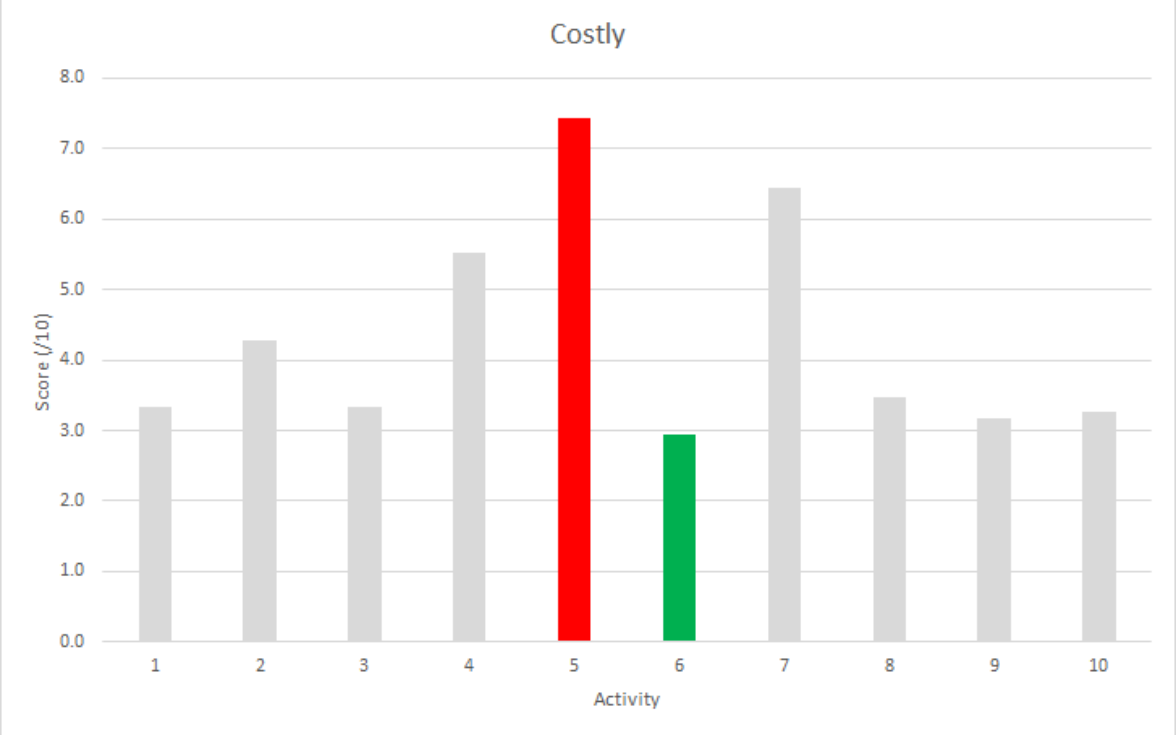
(See Appendix A for legend for Activities)

iii. Willingness to Adopt Each Activity



**(See Appendix A for legend for Activities)*

iv. Perceived Cost of Each Activity



**(See Appendix A for legend for Activities)*

Appendix H: Correlations of Results

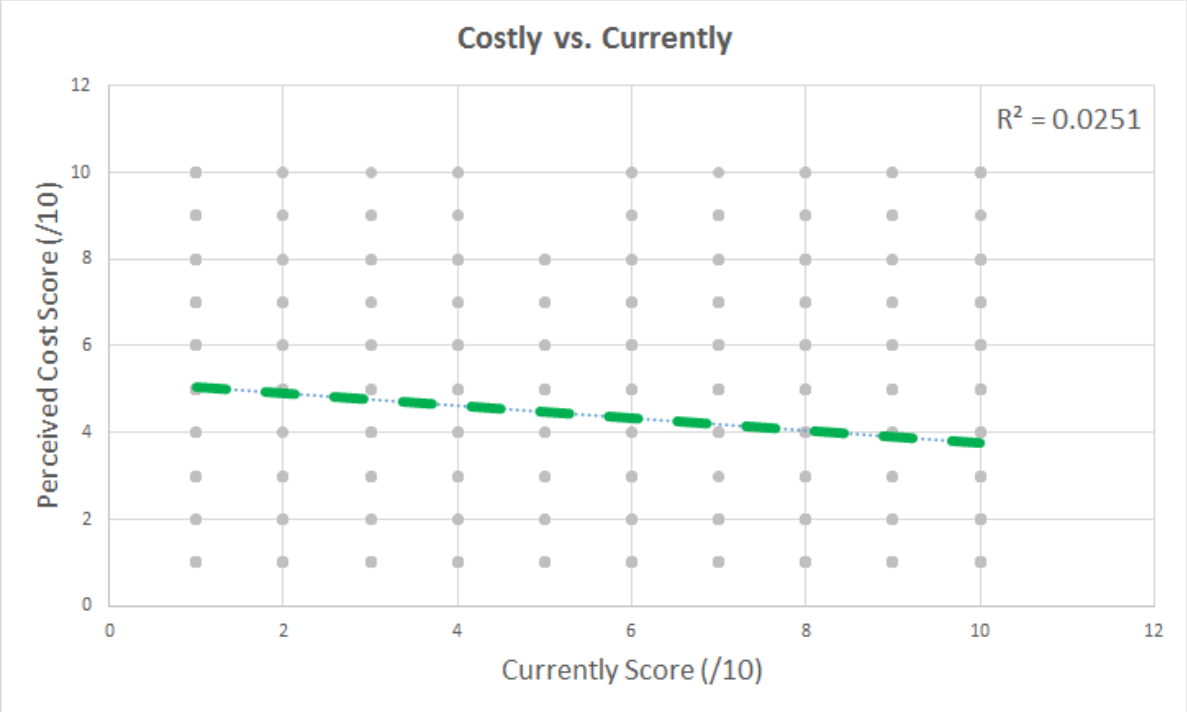
i. Willingness vs. Effectiveness

ii. Cost vs. Effectiveness

iii. Cost vs. Willingness

iv. Effectiveness vs. Currently Engaged

v. Cost vs. Currently Engaged



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