

Promoting Water Bottle Use by Using Persuasive Human Computer Interaction

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Every year, tons of plastic water bottles are disposed of by Americans, affecting entire ecosystems and further contributing to greenhouse gas emissions through the plastic bottle manufacturing process. Since Americans today, and likewise, Villanovans, spend significant time on their phones, is there a way to utilize these devices to get people to act against the harmful disposal of plastic bottles? The concept of persuasive human-computer interaction (HCI) can help to address this issue. Persuasive HCI involves studying how humans interact with computers and implementing persuasive methods into the technology to promote a particular action from the human. Because humans interact with technology now more than ever, utilizing persuasive technology could increase environmental awareness and safe practices. An app that could reward people for filling up their water bottles would potentially prove effective in this way. Additionally, installing additional public water bottle fountains and providing reusable water bottles to people can allow more convenience in sustainability. At Villanova University, to help more students use on-campus, public fountains, an environmental HCI application could apply incentives to encourage an increase in fountain users. With additional reusable water bottle filling stations and a rewarding sustainability app, Villanova students would use reusable bottles more frequently than disposables, therefore diminishing disposable water bottle use on campus.

Introduction

Problem Statement: Along with the rest of the world, Villanova University is suffering from a lack of care toward the issue of disposable water bottle use. Some students do use reusable water bottles, but there are many students who still routinely use single-use plastic bottles. 86% of students reported that they use plastic water bottles at Villanova. Of those students, 91% would be willing to use or attempt to use a reusable bottle (1). While this data was gathered seven years ago, these numbers would seemingly still be high. Furthermore, according to an environmental concern survey we conducted that received 212 Villanova student responses, 95.9% of students support our sustainability initiatives, demonstrating that students want to be more environmentally conscious. We believe that providing incentives to students through persuasive technology can help to increase environmental awareness.

Motivation of Study: Continuously decreasing the number of water bottles produced and used will save energy and decrease the emittance of carbon dioxide into the atmosphere. Now, while Villanova University does recycle plastics, heavy use of its recycling program would be costly. However, this cost might be greatly reduced if Villanova could invest in our reusable water bottle initiatives. Reusable water bottles also allow students to save money by not purchasing plastic bottled drinks. Students can simply refill their water bottles at any of the numerous, refillable Elkay fountains across

campus instead of purchasing additional, plastic bottled drinks.

Statement of Hypotheses: Persuasive HCI techniques can be utilized with students on Villanova's campus. For example, the university has already found success with this concept in its "Nova Athletics" mobile application. Since basketball is important to Villanova, we could connect the success of the "Nova Athletics" app with a similar environmentally-themed point system app. This sustainability application could reward students with basketball ticket points for utilizing the reusable water bottle filling stations around campus. According to our survey of 212 students, 87% of students supported this idea. Paired with university-provided bottles and the installation of additional water bottle fountains, this app can encourage students to be more environmentally-conscious while simultaneously promoting a community sustainability effort in association with basketball.

Assumptions/Limitations: With this application idea, there are several assumptions and limitations. One vital assumption to this operation is that students will not try to cheat the system by constantly refilling water bottles to get points. A time limit system could be implemented to prevent such behavior. For example, students would only be able to receive points in 30-minute intervals to prevent continual refills. This application also has a key limitation that must be considered; since the Elkay fountains do not allow access to internal data, there would need to be some

external method of accessing the fountain data, such as a QR code that students could scan.

COVID-19 Considerations: There is one ethical consideration that is rapidly changing the world and will affect this initiative: COVID-19. While the CDC has reported that drinking water is safe to consume, multiple people pass by drinking fountains and use the actual fountain component. Droplets containing the COVID-19 virus can spread from a person's nose or mouth, settling around the water fountain and possibly landing around the water bottle filling component. While refilling water bottles involves minimal contact with the fountain itself, the fountain is still a public device that people should approach with caution during the global pandemic.

Persuasive HCI Literature

Related Literature: Much of this research project involved applying many of the ideas outlined in a computational sustainability article called "Computational Sustainability: Computing for a Better World and a Sustainable Future," written by Carla Gomes of Cornell, to our concept. After outlining many of the threats to the environment, the article proposes to solve many of these problems with computational sustainability. Examples of these solutions include using satellites and remote imaging for estimation of population data (within impoverished countries with a lack of census data), optimizing individualized transportation options in the urban landscape, and creating citizen science programs to help in gathering observational data (2). Of course, there are many other, unlisted applications. For our project, we decided to focus on the computational model themes that could be directly applicable to and helpful for Villanova University.

Applications: The principal application for Villanova University as discussed in the Gomes article involved the usage of modeling graphs of on-campus water filler data. There are 58 bottle-filling stations around Villanova's campus to which students have direct access. After collecting counter data across these fountains every two weeks and graphically displaying this data, we could confirm a high and steady use of these stations.

The Gomes article also discussed methods of approaching a sustainability plan. Accordingly, an important rule to follow in improving sustainability is connecting initiatives and quite simply "getting the word out" (2). Villanova can improve its efforts in this area.

Many students on Villanova's campus do not know what the Sustainable Leadership Council is, and many others are not aware of the steps Villanova is taking to

promote environmental sustainability as outlined in its new University Strategic Plan. According to our survey, when 212 freshman students were asked to rate their knowledge of Villanova's sustainability effort on a 1-to-5 basis, with 1 being the least familiar and 5 being the most familiar, 83% of students gave responses between 1 and 3, with 19.3% responding with 1. Coordination among various student groups to collectively address this important issue is necessary for greater steps toward a more sustainable university.

Proposed Plan

Three-Part Solution: To solve the environmental problem of disposable water bottles, a three-part solution is proposed. Since additional Elkay refillable water bottle stations are being installed and repaired each year, the fountains are being used daily. The first fountain was installed on Villanova's campus in 2012. In the following eight years, 57 additional fountains have been installed.

First, the school can invest in installing even more fountains so that students are constantly provided with opportunities to fill their water bottles. According to our survey, 95% of students would support the installation of additional fountains. However, some problems students may face with using reusable water bottles stem from a lack of clear incentive; students may already have a system of acquiring plastic bottles, or prices for good quality bottles are prohibitively high.

Secondly, the university could supply every incoming student with a reusable water bottle. According to our survey, 86% of students would use a Villanova-provided water bottle. Both Duke University and the University of Michigan have started programs to give free water bottles to every student. According to an article on Duke Today, "In partnership with the Nicholas School of the Environment, Sustainable Duke provides every first-year student with a reusable water bottle" (3). Similarly, according to Michigan's newsletter, the *University Record*, "In 2012, the university also implemented the Planet Blue Water Bottle Initiative, which supplies all first-year undergraduates and incoming faculty and staff with a reusable water bottle when they arrive on campus" (4). Villanova can adopt this idea, which would give students a clear incentive to use reusable water bottles; not using them would be a direct rejection of helping the environment.

Finally, and perhaps most importantly, Villanova University could implement a mobile application, as discussed previously, that could persuade students to refill their water bottles by giving student bonus points for the basketball ticket lottery. This is where the university-provided water bottles can help, since

the bottles could have bar codes tailored to the surface. Then, at every water bottle filling station, a student could scan their bottle to be rewarded with points. Additionally, there could be a sensor on the fountain to confirm that a certain amount of water is coming out so that students do not just scan their bottles. The application would also use 30-minute intervals to award points, as explained previously. This application would use full stack development, as it would need to provide a user-friendly interface (front end) and communicate with a server-wide point system (back end). This three-part solution can greatly increase reusable water bottle usage at Villanova.

Major Task / Project Management

Description: To perform an analysis on the water fountain collection data, we collected two types of data. The first sample was a generic collection in that we determined the number of bottles each station had filled every two weeks and recorded that data in both a spreadsheet and graph. Because there are 58 fountains at Villanova University, the spreadsheet cannot be represented here due to its sheer size. A graphical representation of 5 of the fountains which consistently displayed data is below in Figure 1.

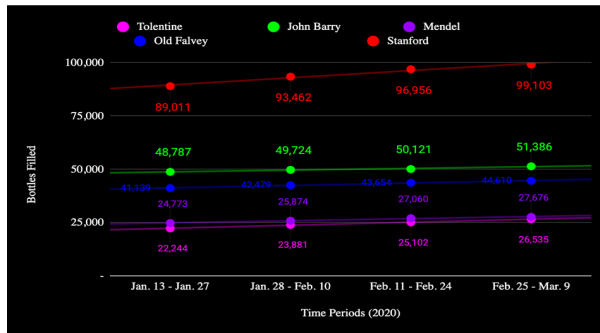


Figure 1. Bi-Weekly Fountain Measurements

The second type of collection we performed only involved one fountain: the fountain on the ground floor of Mendel Hall. For two weeks, on Monday, Wednesday, and Friday, in 10-minute intervals from 10:20-10:30am, 11:20-11:30am, and 12:20-12:30am, we counted the number of people who walked past the fountain while also counting the number of people who used the fountain. The results are displayed in Tables 1 and 2.

Table 1. Data for the Mendel Hall Fountain, Week 1.

1st Week 2020	Monday		Wednesday		Friday		Total	
	People	People who filled	People	People who filled	People	People who filled	People	People who filled
2/10-2/14								
10:20-10:30	115	6	120	7	67	2	235	13
11:20-11:30	141	6	129	7	102	9	270	22
12:20-12:30	93	9	75	3	62	3	230	15

Table 2. Data for the Mendel Hall Fountain, Week 2.

2nd Week 2020	Monday		Wednesday		Friday		Total	
	People	People who filled	People	People who filled	People	People who filled	People	People who filled
2/17-2/21								
10:20-10:30	96	4	104	5	31	1	231	10
11:20-11:30	177	14	92	7	82	6	351	27
12:20-12:30	95	9	64	4	65	3	224	

Furthermore, we created a Google Forms survey with these four questions:

1. On a scale from 1-5, how informed do you think you are regarding Villanova’s sustainability initiative?
2. Would you use a Villanova-provided, reusable water bottle?
3. Would you support an initiative that proposes additional water bottle fountains around campus?
4. Would you use a Villanova sustainability app that rewards you with more Villanova basketball points for using your reusable water bottle with the fountains?

We recorded responses from 212 students in the Class of 2023 using entire dorm chats and the Facebook Class of 2023 Facebook group. The results are displayed in Figure 2 on the next page.

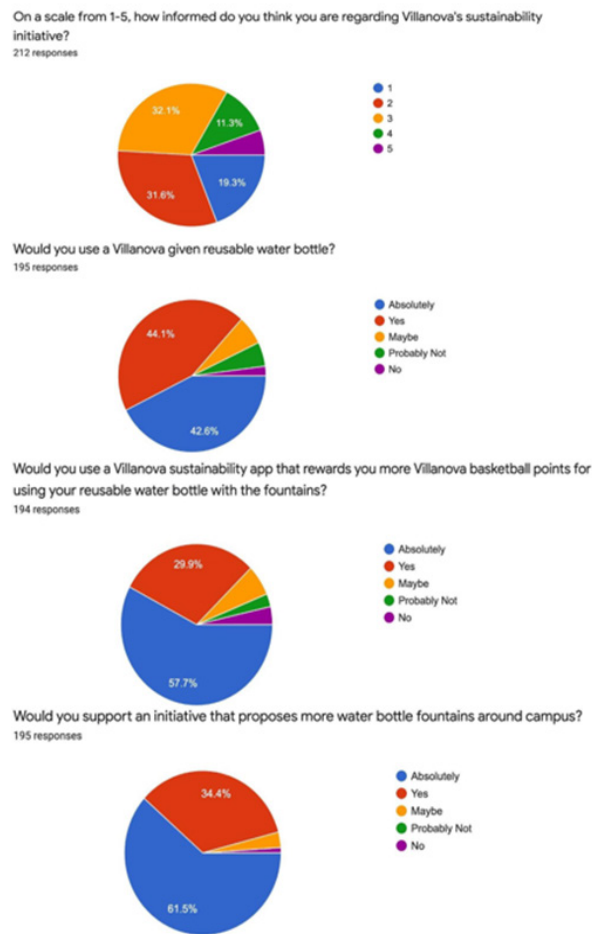


Figure 2. Google Survey Results.

Data Analysis

Mendel Ground Floor Collection: From our measurements taken three times a week, we calculated that on average, 6.56% of all people who walked by the Mendel ground floor fountain used it. Unfortunately, due to COVID-19, there was not adequate time to measure the impact that a persuasive HCI initiative would have on the percentage of people who utilized the fountain. Nevertheless, since our survey showed that a large majority of students support the initiative, it is plausible that an incentive-producing application or simple poster, for example, would have prompted more people to utilize the water fountain.

University-Wide Collection: Perhaps the most important finding from our university-wide collection was that there appeared to be a steady, linear rate of use of the reusable water fountains, as seen Figure 1. Freshman dorms such as Stanford seemed to perform best in comparison to other dorms with a high

average of 3364 bottles filled every two weeks. This is perhaps a sign that the freshman class will be more environmentally conscious.

During our study, we discovered some interesting details which could have possibly discouraged students from utilizing the fountains. Primarily, 16 of the 58 water bottle stations on campus produced no reading on the water bottle counter, which meant that we were not able to collect data from all 58 stations. Also, there was always a good percentage, around 20%, of the water bottle stations that needed a filter change immediately or very soon. This “filter change issue” could possibly dissuade many Villanovans from utilizing the water stations; the fountain on the first floor of Bartley Hall on the Lancaster side of the building is a great example of this phenomenon. For a while, its filter check indicator was red, suggesting that it required a change very soon. In the span of approximately seven weeks, from around January 13 until around March 9, the filter recorded a mere 3402 bottles filled. At the same time, the water bottle fountain on the third floor of Bartley recorded approximately 8135 bottles filled. This is interesting due to the fact that one would presume that the first-floor fountain of Bartley would receive much more foot traffic than the third floor fountain.

Survey Data: According to our survey’s results, most students are interested in making Villanova a more environmentally friendly place. Our surveys concluded that 86% of the student population supports our three sustainability initiatives. Moreover, 95% students would support more water bottle filling stations being installed throughout campus. Additionally, 86% of students would use a Villanova given water bottle and 87% of students would use a sustainability app. However, students showed that they are not well informed of university sustainability initiatives with 83% responding with between 1 and 3 on a 1-5 knowledge basis score.

Conclusion

Summary: Water bottle plastic is a major source of eliminable waste that is produced on the campus of Villanova University. There are many water bottle filling stations on campus, but a mere 6.56% of foot traffic by a certain water station on campus suggests that these stations are being underutilized. Lack of usage of the water bottle filling stations suggests that members of the Villanova community simply do not have water bottles that they carry around with them, or they may lose their reusable water bottles. Thus, instead of utilizing the stations, students purchase water bottles in the many convenience stores around Villanova’s campus that sell them or simply drink from the plastic cups offered in the dining locations around campus.

Impact: Unfortunately, due to COVID-19, there was not adequate time to test and measure the impact of persuasive HCI initiatives on use of water bottle filling stations. However, in agreement with our environmental concern survey, it is quite possible that constant reminders of the necessity to protect the environment and incentives to do so would result in better utilization of the water stations. We determined that an initiative of implementing more refillable bottle stations, implementing an application system in conjunction with the basketball points system to promote more fountain use, and giving every student a refillable water bottle at the beginning of the year could drastically help Villanova's sustainability initiatives. While the university has mainly turned its attention to managing the new COVID-19 guidelines on campus for the 2020-2021 school year, it can provide reusable water bottles and implement an app as early as the 2021-2022 school year. It can also continue to install additional water fountains. These important steps could make Villanova University a leader in campus sustainability.

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REFERENCES

1. Chudwick, Emma & Salvemini, Maria & Welker, Alissa. "Implementing Water Refill Stations Across Campus to Promote Reusable Water Bottle Use." Dept. of Geography and the Environment, Villanova University, 2013.
2. Gomes, Carla, et al. "Computational Sustainability: Computing for a Better World and a Sustainable Future." *ACM*, 1 Sept. 2019, cacm.acm.org/magazines/2019/9/238970-computational-sustainability/fulltext.
3. Roth, Bryan. "Campus Water Stations Save 400,000 Plastic Bottles." *Duke Today*, 27 Oct. 2015, today.duke.edu/2015/10/hydrationstations.
4. Thwing, Susan. "Additional Water Refill Stations Coming to Campus This Summer." *The University Record*, 13 May 2016, record.umich.edu/articles/additional-water-refill-stations-coming-campus-summer/.



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Lucas Deane is a member of the Villanova Class of 2023. He is majoring in Computer Science with a minor in Business. He is involved in the Association for Computing and Machinery on campus and plans on enrolling in the MS in Software Engineering program at Villanova to pursue his career as a software engineer. He is passionate about coding projects that aim to solve real-world problems, such as climate change. Thanks to the Villanova Match Research Program and the Department of Computing Sciences, he was able to research the application of computer science concepts to the university-wide issue of plastic consumption. Lucas is a Villanova Presidential Scholar.



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Nicole Keane is a member of the Villanova Class of 2023. She is majoring in Mathematics. Originally from Raleigh, North Carolina, she hopes to return there to pursue a Master's in Data Science after graduating from Villanova. On campus, she is a part of the Association of Women in Mathematics (AWM) club. She would like to extend her thanks to the Villanova Computer Science Department, the Villanova Match Program, Dr. Robert Beck, and her fellow researchers for the opportunity to explore computing sciences.



Mentor

Dr. Robert E. Beck

Dr. Robert Beck has directed student research for many years and has seen a number of his research students pursue research careers in universities and corporations. In 2014 he received the National Center for Women in Information Technology Award for Excellence in Undergraduate Research Mentoring. In his role as founding chair of the Department of Computing Sciences, he has encouraged students to think creatively and to learn outside the classroom walls.



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Eric Lavin is a member of the Villanova Class of 2023. Eric is originally from Newfoundland, NJ and is majoring in Mathematics and Computer Science. He plans to work in software engineering, finance, or law after college. One of his passions is research, and this project certainly excited that passion. He finds it extremely fulfilling to put time, work, and effort into a project that will hopefully have a positive impact on others. Eric thanks the Villanova University Department of Computing Science, the Match Research Program, and the entire research team; the project could not have been more of a success, especially during the COVID-19 pandemic.