UNIVERSITY of VIRGINIA

SCHOOL of ENGINEERING & APPLIED SCIENCE

ENGR 1020 Final Report

WHEELS OF CHANGE

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DRAFT REPORT:

ENGR 1020 Final Report

Project:
Wheels of Change

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STAB	St. Anne's Belfield

EXECUTIVE SUMMARY

St. Anne’s Belfield school is a local Private school in Charlottesville, VA serving about 900 students in the area. The school is split into two campuses: a K-8 school and a 9-12 school. Since it is a private school, parents are tasked with picking up their own children daily. In addition to that, students are active participants in athletic programs which causes pickup schedules for those students to vary excessively. Unfortunately, the K-8 school has become victim to severe congestion during dismissal times. This has led to pick up times stretching to 40 minutes. Many factors contribute to this mayhem. Sometimes, parents come at the wrong times to pick up their children which can lead to congestion. Other times, sports schedules cause conflicts and confusion that makes it harder to organize pickup times. Lastly, in the greater context of where the school is located, there is generally an abundance of traffic on the roads surrounding St. Anne’s. This has resulted in unhappy parents, and greater costs for the school as they must pay for overtime and other costs. Therefore, this group has been tasked with coming up with an effective and cost-efficient way of reducing traffic.

The main issue at hand was identified to be the number of cars that go through the K-8 campus. The greater number of cars, the greater the congestion. As a result, this group aims to reduce traffic and congestion by reducing the number of cars on the road. We aim to do this by incentivizing or increasing the number of parents who choose to carpool to pick up their children and other children. The initial prototype proved that a system could be created that monitors and tracks carpools. Once the carpools are properly monitored, it would be possible to randomly select individuals based on the amount that they carpool. Those who were selected are then awarded a prize. With the incentives in mind, parents of St. Anne’s would ideally carpool more. Carpooling more would then result in less cars occupying the roads and would result in less traffic.

The point system, as described in more detail in later sections, works as follows: the parent doing the driving would earn a point or entry for driving AND they would earn additional points or entries for each student driven outside of their household. The students outside of the household would are participating in the carpool system would also gain points. All this data would then be stored in PikMyKid or Veracross, both of which are apps that parents of St. Anne's already utilize regularly.

Our testing for this project included asking general feedback from students who used the end user interface to see if it was intuitive. Also, we surveyed parents for their opinion on whether they would take advantage of a carpool system. Finally, we used some extreme test cases regarding whether our data sets would be able to accommodate special case scenarios. Overall, all tests proved to have positive results in regard to how our UI would work and how parents would interact with our UI. Although we were never able to directly survey the parents of St. Anne’s or implement the solution at the school, it is safe to say that the solution would work as parents would be incentivized by the system.

1. INTRODUCTION

1.1 Client Problem

Our client, St. Annes Belfield School in Charlottesville Virginia, is experiencing congestion at their Belfield campus, with pick-up times exceeding forty minutes in some cases. This is due to many factors, such as overlapping pick-up times, especially on Fridays, a misused off-ramp nearby, and parents arriving far too early. There is very little if any budget available for any potential solution.

1.2 Objective and Approach

Our approach was to have fewer cars participating in the car line. Due to budget restrictions, many ideas we had regarding construction or labor were sidelined. Another consideration was user experience, in this case being the parents and students participating in the car line. A good solution will decrease the time they spend in car line with minimal disruption to the routine and

1.3 Report Organization

The following report is structured as follows:

The problem definition and background section contains the literature review which outlines data about carpool traffic in other areas. The problem definition describes how we approached the problem and limitations we faced.

The initial solution ideation section describes how we researched three main designs and narrowed it down to one. We outlined a detailed description of our final solution.

The testing results, analysis, and design revisions section details how we tested our solution. Since we implemented a software solution, we tested the usability of the software with our professor and peers.

The summary and final solution section showcases the final solution with revisions. A reflection of the final solution is also in the section.

2. PROBLEM DEFINITION AND BACKGROUND

2.1 Client Interview Summary

To better contextualize the problem at hand and to see the bigger picture, we were given the opportunity to interview the principal of St. Anne's Belfield school, Autumn Graves and the Director of Facilities and Security, Pete Commons. Questions that we had ready to ask included asking what had already been implemented, what current transportation for students is like, and are parents satisfied with the current system. The interview started off with an overview of the current situation from the perspective of the client. They narrowed down the issue into 4 main parts: no jurisdiction on roads that are on the campus, a misuse of roads outside of the campus area, an increase in development of nearby neighborhoods and a disorganized dismissal system.

A main issue that contributes to the heavy volume of traffic is the school's inability to change the roads and structure of roads that "lie" on their campus. This is because a certain section of the road is not owned by St. Anne's. Therefore, the school has no jurisdiction and is unable to make changes that may help the flow of traffic. As a result, utilizing the roads in the most efficient manner is vital to help the flow of traffic. However, that is currently not being done for a variety of reasons according to the client. The client believes that parents do not follow the dismissal times for students correctly. In other words, they show up earlier than necessary which causes backup at the campus. This results in the time between 2:45 and 3:10 to be extremely backed up resulting in pick up times of about 40 minutes.

When a parent is successfully able to leave St. Anne's campus, another issue arises. Parents must merge onto US 250. US 250 is a notorious road known for traffic. A large issue associated with this road that contributes to traffic, according to the client, is that people use the road to decrease their travel time rather than using an alternate route that decreases traffic for parents having to pick up their children. This misuse of roads creates unnecessary and preventable backup for multiple groups of people. However, the client does feel hopeful regarding this issue as VDOT is currently working on a project to address this issue. Therefore, we are not concerned about this aspect of the issue and will not be addressing it.

Third, the client has identified the recent development of the Crozet neighborhood in Charlottesville as a reason for the increased volume of traffic. The development has brought new residents to Charlottesville and drivers who utilize US 250. This, in addition to the parents picking up their children, has resulted in even more traffic for parents trying to leave St. Anne's. This is not an issue that can be solved but will aid in contextualizing the issue at hand.

Lastly, the client has identified that the dismissal times within the campus to be a cause of issue. Due to the different age groups and needs of those age groups, a dismissal schedule has been made to meet those needs. However, for parents with children in multiple age groups, this has proved to be an inefficient idea as children are forced to wait for a longer time while parents are forced to wait in their cars for a longer time.

Due to the wide variety of components and contributing factors outlined by the client, we are looking to create and design a multi-faceted solution that will help parents pick up their children a lot faster and exit the campus area in less time. The client additionally expects us to primarily focus our efforts on addressing issues relating to fixing traffic issues *on* the campus rather than looking at the issues surrounding the campus area.

Customer Discovery

This problem mainly concerns parents who are picking up their children, the children who need to be picked up and are often waiting outside, the teachers and staff who are at the school overtime to oversee the dismissal problem and finally other drivers on the same roads that are being used by parents. A common theme amongst all these groups is that they would love to wait less in traffic. It is for that reason that the overall goal in this problem is to reduce time waiting in traffic. Based on the client interview and the review of the various collected sources, the best way to approach this issue is to look at the current dismissal routines of St. Anne's and find a way to restructure the routine to allow parents some more leeway as a way to decrease traffic flows across the school.

Literature Review

St. Anne's Belfield school has become victim to the severe impacts of traffic congestion which has resulted in extended pick-up times, frustrated parents and staff, and a dissatisfied driving experience. To fully contextualize and understand the issue impacting the greater community of St. Anne's, a wide variety of sources were collected and analyzed. Sources range from how to map traffic patterns, impacts of traffic on the environment, and prior solutions that may or may not have solved a similar issue.

Mapping the problem

The St. Anne's school utilizes a dismissal flow that mimics a counterclockwise circle. Unfortunately, most of the road leading parents through the dismissal circle is a single lane road that stretches around the school ("St. Anne's Belfield," n.d.). During peak times of traffic, students are forced to wait outside while their parents come to pick them up. This leads to the children becoming restless as a result. To better analyze the flow of traffic to ensure that students are not waiting outside for an extended period, researchers have found and implemented effective ways of modeling a wide range of traffic issues (Zhao, et al., 2022). This analysis includes making predictions based on linear statistical theory, non-statistical theory and artificial intelligence theory. Due to this analysis, people can predict when traffic will be greater. In the grand scheme of the overarching issue, being able to collect data from parents regarding their uses of the road and how traffic affects their experience in picking up their children will result in being able to better map out the traffic patterns and make any necessary changes.

Safety Concerns of Traffic Congestion

Increased traffic around schools causes idling and increases air pollution in the area. Pollutants caused by automobiles include nitrogen oxides, sulfur oxides, elemental carbon, black carbon, and ozone (An et al., 2021). For traffic congestion around schools, this air pollution may have a greater adverse effect on children as younger children are more susceptible to pollutants in the air (An et al., 2021). Air pollution can cause a range of health issues, including respiratory and cognitive decline. Specifically, a longitudinal study on the effect on air pollution on cognitive development in school children found that children exposed to higher levels of air pollution displayed slower working memory (Forns, et al., 2017). The negative relationship between air pollution and the health of children has been well established, thus it is imperative that schools prevent the over-exposure of pollutants by minimizing traffic congestion during pick-up and drop-off times.

More traffic congestion around schools could also increase the chance of injuries due to pedestrian-vehicle collisions. Oftentimes around schools, these pedestrians are children who may not be educated on traffic safety, including rules like "look both ways before crossing the street." In the United States, while pedestrian deaths have declined over the past 30 years, child pedestrian deaths have increased by 11% since 2013 (American Academy of Pediatrics, 2023). These statistics demonstrate that policies to improve traffic congestion around schools must place the priority of child safety first. In its 2023 yearly report on child pedestrian safety, the Americans Academy of Pediatrics recommended that schools promote walking as an alternative to motorized transportation and reducing speed limits in urban areas.

Prior art

Traffic congestion around schools is a common issue that affects schools around the globe. A case study conducted on primary schools in Beijing found that schools increased localized traffic congestion by 4.5 percent (Sun et al., 2020). Sun et al. (2020) proposed two solutions to alleviate traffic conditions in Beijing primary schools: staggering hours and using school buses. In Beijing, private schools tend to emulate public schools in the United States, thus this leads to Beijing private schools having a bus system. Beijing private schools tend to produce less traffic than public schools because of these bus systems.

To decrease the amount of congestion around schools, a potential solution is to "educate parents about their children's using alternate transportation modes" as well as "ways that parents play a role in reducing congestion and increasing student safety" (Vigne, n.d.). Another solution is encouraging students to walk or bike to school, but this must be accompanied by limiting the amount that students must bring to and from school (Vigne, n.d.). Walking and biking to school not only improves congestion but can also be presented to improve health. Students in China who biked to school had higher self-rated mental and physical health status, a healthier weight, and lower stress (Ding et al., 2023).

Another solution that may be effective is using an app so that students and staff at the school know when their parent/guardian has arrived, so that students can go to their pickup vehicle as soon as it gets there. "This will minimize the parents' waiting time at the pickup lane and thus reduce waste of petrol consumption and air pollution." (Law et al., 2023). At St. Anne Belfield, an app called Pikmykid is being used to fulfill this purpose, but the difference in parent wait times before and after the app implementation is unknown. The problem persists despite the use of the app.

The Virginia Department of Transportation has recently taken initiative to solve the issue of increased traffic outside of the St. Anne's campus. This is known as Project Pipeline and it addresses the issue of traffic on US 250 and the merging process off of Faulconer drive onto US 250 ("VA Project Pipeline," n.d.). Unfortunately, this project is behind schedule and not many tangible successes have been recorded. On the bright side, however, this further emphasizes that the traffic issue in this area must be addressed, and changes must be made.

The current state of the research of school traffic reveals a multifaceted problem with factors ranging from environmental, health, and safety, to education on traffic mitigation. The issue is highly nuanced, and there are gaps in research, especially on effectiveness of potential solutions, but valuable insights were gained, especially in safety of students due to traffic. Based on this information, a solution prioritizing safety while reducing parent wait times and increasing satisfaction among users must be implemented.

2.2 Problem Definition

St Anne’s Belfield is a private school serving about 900 students across two campuses. The campus on Faulconer Drive, serving pre-k 2 through eighth grade, has severe traffic backup at pickup times. This has led to the pickup line exceeding forty minutes, causing frustration among parents. The client believes that traffic congestion on the campus is strongly tied to how difficult it is to get off of Faulconer Drive due to merging onto US 250. In addition to that, parents often incorrectly practice the pickup times for their children and will show up at wrong times which results in more congestion. With an increasing concern about congestion of cars and time lost due to traffic, parents are forced to wait close to an hour simply to pick up their child. On the other hand, most children wait outside for their parents, further causing distress. The main design limitation for a new arrival and dismissal system is the budget. The consequence of a lack of budget means that no large construction projects can be undertaken, and no extra staff can be hired at pick-up time. There are two main factors that define the success criteria: a decrease in waiting time and happier users. In order to determine whether there is a significant decrease in the average waiting time during pickup, data must be collected on waiting times and the number of cars that come in and out. Quantifying happier users can be conducted through surveys from both parents and children.

3. INITIAL SOLUTION IDEATION

3.1 Development of Alternative Designs

There were 3 designs that we investigated implementing.

Design 1

The first design that we researched into implementing was the Shuttlebus Solution. To minimize the volume of traffic during pick-up, a shuttle bus would drive students to a secondary location. Parents would pick up their children from this secondary location. While we investigated several secondary locations, ultimately, we decided that the best secondary location would be the alternate Saint Anne's Campus. Upper-level students or students with siblings would have priority for a shuttle bus system. The picture below demonstrates the bus route for the shuttle bus.

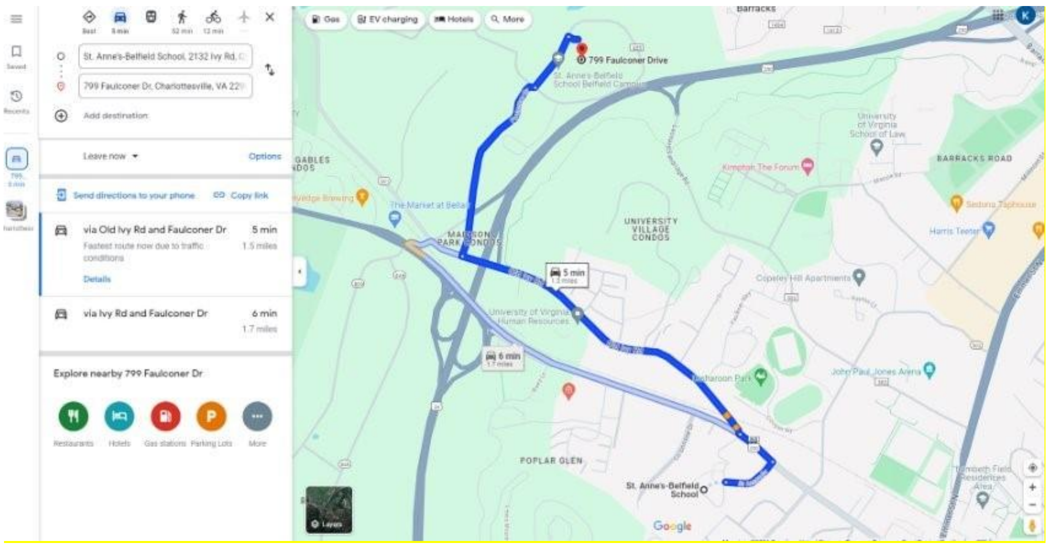


Figure 1. Map of route from STAB's upper to lower campus

Design 2

Another potential solution was to change the dismissal times. Currently, the pick-up times for K-4 and 5-6 occur at 3:15 - 3:35 and 3:35 – 3:55, respectively. While the pick-up times technically do not overlap, parents oftentimes arrive before and after these times, which causes a large traffic buildup especially around 3:35. Thus, a potential solution was to alter the dismissal times such that there is less overlap between the K-4 and 5-8 pick-up times. The chart below shows the current pick-up schedule.

Table 1. STAB dismissal times

Grade	Dismissal Times
K-4	3:15 – 3:35
5-6	3:35 – 3:55
7-8	<u>Athletics</u> • Mon – Thurs: 4:10 • Fri: 3:35 <u>Off-Season</u> • Mon – Thurs: 2:45 • Fr: 3:35

Design 3

Our third potential solution was implementing a carpool incentive system. Creating incentives such that more households carpool, especially during pick up, would reduce the total volume of traffic. Using PikMyKid, a carpool app that parents already use during drop-off and pick-up, Saint Anne's would track how often households carpool and convert it into a raffle system, where the more a household carpools, the more entries they have in the raffle. Prizes for raffles include class parties, gift cards, and discounted tickets to galas and events.

Figure 2. Graphic supporting carpooling

3.2 Selection of Initial Design

To quantify which design would work the best, we implemented a decision matrix.

Table 2. Decision Matrix

Idea	Cost	Complexity	Development Time	User experience	Total (out of 40)
Carpool incentives	1	5	3	2	11
Shuttle bus to alternate location	8	8	6	5	27
Dismissal time changes	4	6	5	3	18

1 (Excellent)	10 (Poor)

Ultimately, we chose to move forward with the carpool incentives idea. Our main motivation for choosing carpool incentives was the cost. Since we did not have a budget, we picked the option that provided a very low cost. Other factors, such as complexity and user experience, also helped make our final decision. The decision matrix displays how the carpool incentives idea was by far the best of the three ideas.

The shuttle bus solution was not feasible due to the high cost. Hiring extra staff as bus drivers would cost too much to be a good solution. Furthermore, parents may not be happy with their children being driven to a secondary location, lowering the user experience. The dismissal time changes were also not a feasible option because it would cause a cascade of issues as most parents have a definitive schedule for drop-off and pick-up each week.

3.3 Detailed description of design

Our design is called: Wheels of Change. We aim to implement a carpool incentive system to minimize the number of cars in the carpool lines during pick-up. There are three main steps to our design: tracking carpooling using PikMyKid, creating incentives for families, and implementing a raffle system to award the winners.

Firstly, for tracking carpooling, we are planning to use the PikMyKid API to track the carpooling and turn it into a point system. The point system works as follows: the driving family earns one point for driving, and an additional point for every student driven outside the household. The other families earn one point for each student driven within their household. The charts below illustrate how a point system may work.

Furthermore, parents will be able to find other households in the area via Veracross. Veracross has a preexisting function that allows parents to track the addresses of other households, thus, implementing a "families within a 5-mile radius" option will not require much more implementation.

Table 3. Point system for carpooling families

Family	Entry
Driving family	1 for driver 1 for each student from other families
Other families	1 for each student driven

Table 4. Example of how points are delegated

	Driving Family	Household #1	Household #2
Points	1 for driving 2 for driving 2 students	2 for student driven	1 for student driven
Total Points	3	2	1

Secondly, to create incentives for families, a raffle system will be implemented where each point is an additional entry into the raffle. Parents can win a variety of prizes from the raffle including Nintendo Switches, iPads, and other electronics and toys. These prizes can also include gift cards and prioritized seating during school events. A survey for the parents could also be conducted to find what types of incentives might work better than others.

Lastly, for implementing a raffle system, Veracross can be used to promote and announce winners of the carpool. Parents already use Veracross to check grades and activities, thus, incorporating a raffle tab in Veracross will be convenient for parents and the school alike.

The flow chart illustrates how software will be used for our solution:

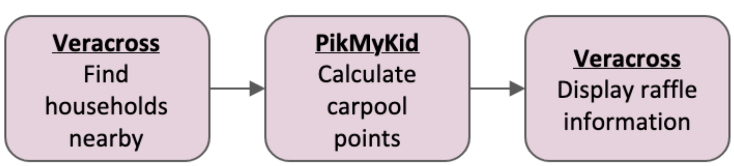


Figure 3. Flowchart of how software will be used (chronological)

4. TESTING RESULTS, ANALYSIS AND DESIGN REVISIONS

4.1 Initial fabrication and testing plan

4.1.1 Test 1: Usability test

To test the usability of the software, we will receive feedback from our peers on the usability of the interface. We will guide the subjects through the website which includes the page to the raffle information. After the subjects go through the website, a survey will be conducted to receive feedback on how usable the website is.

The questions on the survey will include:

1. On a scale of 1 to 10, how easy was it to find the raffle information?
2. On a scale of 1 to 10, how professional does the website look?
3. Is there anything else that we could improve on?

After gathering the information, we will have 2 variables for quantitative data, and 1 source of qualitative data. For the quantitative information, we can assume that the average answer (null hypothesis) would be 5. Thus, we can analyze our results in comparison to a known average of 5 for the null hypothesis.

Our qualitative results will provide the most immediate feedback. The results will inform us of specific areas that we can improve on. The quantitative results will inform us of how we can improve the usability and the professionalism of the page. If the average mean for both variables is less than 7, we need to focus more on usability and professionalism.

4.1.2 Test 2: Parent satisfaction test

To understand the satisfaction that parents have regarding the carpool incentive system, it would be ideal to survey the parents about their opinion. This can be done by sending out a google to the parents of St. Anne's. The form will consist of asking questions pertaining to the current state of the traffic system, their experience with the current system and more. Additional questions will include what their opinion is regarding changes that are going to be made in a quantitative way. This means ratings on a scale of 1-10 will be used to understand if the overall opinion is positive regarding the new changes. Finally, to understand what types of incentives the parents will enjoy, the survey will include questions directly asking the parents what incentives they would prefer. It would also ask them to rate the ideas for incentives on a scale of 1-10 with 1 being no satisfaction and 10 being full satisfaction.

Measured values will include rankings that the parents input themselves. Most measurements are based on rankings where 10 is full satisfaction and 1 is no satisfaction. After all data is collected, an average value will be calculated to understand how parents feel about various aspects of the proposed solution. The test will be repeated once to have the most accurate results or the highest number of responses.

If the results are overwhelmingly low or the average satisfaction is below a value of 5, then changes will be made to those specific sections of the solution. For example, if parents decide that the current incentives are poor, it would be ideal to look at their feedback and change the incentives accordingly.

4.1.3 Test 3: Extreme test cases

To determine the reliability of the program we will create for our prototype, we will create test data sets and their expected output and compare the expected output to the actual output. Many data sets will be created, with varying levels of correctness and complexity. Our program should be able to identify data that is the wrong type and data that is outside of a reasonable or possible range. Our program will be judged based on how many test cases where the expected and the actual output match out of how many test cases total.

The percentage of test cases passed will give us a good idea of how reliable our program is, and the closer to 100% the better. We can also use the test cases to find what specific test cases return poor results, which can be used to fix bugs and improve our program. Later on, we can use the manual review process to determine which dataset errors are most common, update the program to automatically fix the errors it can, ignore the errors that don't matter much or are impossible to fix, and request manual review for errors that matter and cannot be automatically corrected.

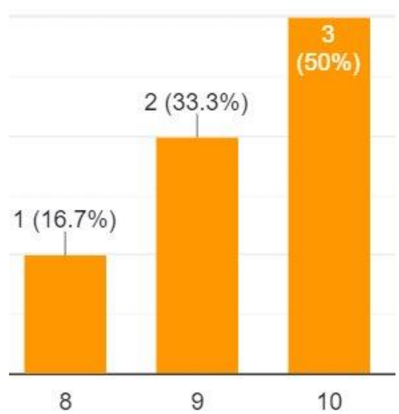
A successful solution should pass at least 90% of the test cases, where the expected output matches the actual output. The program should be able to identify at least 90% of the incorrect data points and be able to display these for debugging purposes as well as manual review and correction. It should be able to automatically correct at least 60% of correctable errors and should ask for manual review for all errors that are not corrected automatically.

4.2 Testing results and analysis

4.2.1 Test 1: Usability test

Overall, the users found the user experience straightforward and easy-to-follow. By guiding the users through the website, they were able to locate the raffle page. Most of the feedback was positive, however, some users found the raffle page confusing. Since we did not debrief the users on the reason behind the raffle page, we concluded that the raffle page needed more background information. Table ## demonstrates how users were satisfied with the interface.

Table 5. Frequency vs Experience (1-10)



4.2.2 Test 2: Parent satisfaction test

Unfortunately, we were not able to gather data from STAB parents. Although we sent a form out, we were unable to procure responses after a week. Thus, we decided to gather qualitative data from Professor Starling who was children who are students at STAB. Overall, we received positive feedback from Professor Starling.

More constructive feedback mostly focused on improving the prizes in the raffle. The prizes in the raffle were mostly monetary incentives, such as electronics or reduced ticket pricing, which may not appeal to all households. One potential non-monetary incentive that was introduced as a fast-pass lane for carpool cars. While we did explore the idea, ultimately, the extra cost needed to maintain and verify the carpool lanes outweighed the benefits.

Another area of feedback revolved around Veracross, the website that all STAB parents use to check their children's grades, teachers, etc. Veracross already incorporates a "find parents nearby" feature, so implementing that feature into Veracross would not require extra paperwork or coding from scratch.

4.2.3 Test 3: Extreme test cases

To ensure the software worked correctly, many test sets of data were created which could be used to compare the script and application output to the expected behavior. Datasets with varying numbers of students, varying completeness of carpool history data, and varying correctness of carpool history data were created. The program should be able to identify appropriate issues with the datasets, and either provide a warning and continue or provide an error and stop.

The number of students does not significantly affect the performance of the application. Much of the current limitation lies in the way the map of nearby families is generated, which is independent of the number of nearby families.

The completeness of carpool history data was addressed by only considering the data given to the application. The program does not currently check that every student has an entry in the carpool history dataset. This is because if a student does not attend school that day, there should be no notification that there is a problem with the dataset.

The application correctly identifies errors with dates provided in the dataset that are outside of the range of when the application was created to when it is run. If a date or time occurs in the future, or too far in the past, the program messages the user the rows in the dataset to inspect.

The application recognizes when an address listed in the student database is not in the application's address book. The application recognizes when the carpool history states that a student was driven, and erroneously states that they also drove other students.

The application provides appropriate warnings and errors for all datasets with incorrect data. The correct number of raffle points and nearest family maps are calculated and generated for all correct datasets we created.

4.3 Informed design revision

Most of the feedback was positive, thus we did not need to make many design revisions. We mostly focused on improving the prizes in the raffle to better fit the needs of STAB parents. We incorporated more STAB-focused prizes including gala tickets. STAB hosts a gala every year to raise money for the school; these gala tickets can be very expensive. Thus, having reduced ticket prizing to carpooling families would be a great motivator to encourage more households to carpool.

Furthermore, we decided to make our software solution as a model for how STAB might implement the design. Thus, much of the software solution was pseudocode that displayed how a carpool incentive system could be advertised using products that STAB parents already utilize. This meant using API and screenshots from PikMyKid and Veracross as a demonstration of a final solution.

5. SUMMARY OF FINAL SOLUTION

5.1 Description of final design

[Include drawing, description of form of client design]

Our design is called: Wheels of Change.

We aimed to implement a carpool incentive system to minimize the number of cars in the carpool lines during pick-up. There are three main steps to our design: tracking carpooling using PikMyKid, creating incentives for families, and implementing a raffle system to award the winners.

Firstly, for tracking carpooling, used the PikMyKid API to track the carpooling and turn it into a point system. The point system works as follows: the driving family earns one point for driving, and an additional point for every student driven outside the household. The other families earn one point for each student driven within their household. The charts below illustrate how a point system may work.

Furthermore, parents are able to find other households in the area via Veracross. Veracross has a preexisting function that allows parents to track the addresses of other households, thus, implementing a "families within a 5-mile radius" option did not require much more implementation.

Table 6. Point system (revised)

Family	Entry
Driving family	1 for driver 1 for each student from other families
Other families	1 for each student driven

Table 7. Example of driving children from different households

	Driving Family	Household #1	Household #2
Points	1 for driving 2 for driving 2 students	2 for student driven	1 for student driven
Total Points	3	2	1

Secondly, to create incentives for families, a raffle system was implemented where each point is an additional entry into the raffle. Parents can win a variety of prizes from the raffle including Nintendo Switches, iPads, and other electronics and toys. These prizes can also include gift cards and prioritized seating during school events. A survey for the parents was conducted to understand what incentives they prefer. After the results, it was clear that parents would be reactive to varying incentives.

Lastly, for implementing a raffle system, Veracross was used to promote and announce winners of the carpool. Parents use Veracross to check grades and activities, thus, incorporating a raffle tab in Veracross was convenient for parents and the school alike.

The flow chart illustrates how the solution works:

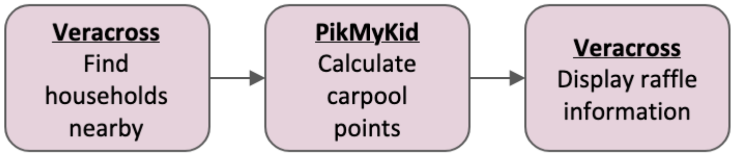
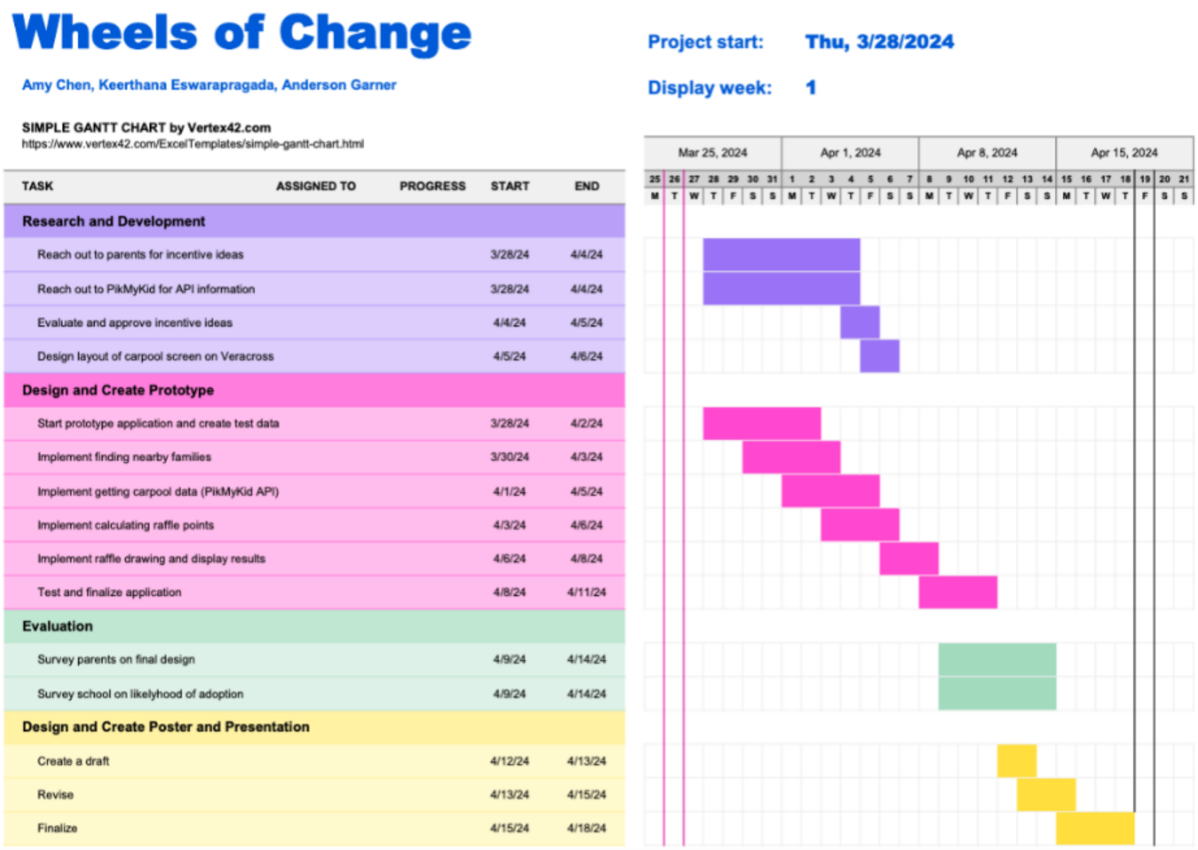


Figure 4. Revised flowchart of software solution

5.2 Fabrication Workflow and Schedule



TASK	ASSIGNED TO	PROGRESS	START	END
Research and Development				
Reach out to parents for incentive ideas			3/28/24	4/4/24
Reach out to PikMyKid for API information			3/28/24	4/4/24
Evaluate and approve incentive ideas			4/4/24	4/5/24
Design layout of carpool screen on Veracross			4/5/24	4/6/24
Design and Create Prototype				
Start prototype application and create test data			3/28/24	4/2/24
Implement finding nearby families			3/30/24	4/3/24
Implement getting carpool data (PikMyKid API)			4/1/24	4/5/24
Implement calculating raffle points			4/3/24	4/6/24
Implement raffle drawing and display results			4/6/24	4/8/24
Test and finalize application			4/8/24	4/11/24
Evaluation				
Survey parents on final design			4/9/24	4/14/24
Survey school on likelihood of adoption			4/9/24	4/14/24
Design and Create Poster and Presentation				
Create a draft			4/12/24	4/13/24
Revise			4/13/24	4/15/24
Finalize			4/15/24	4/18/24

Figure 5: Planned Workflow Gantt Chart as of 3/28

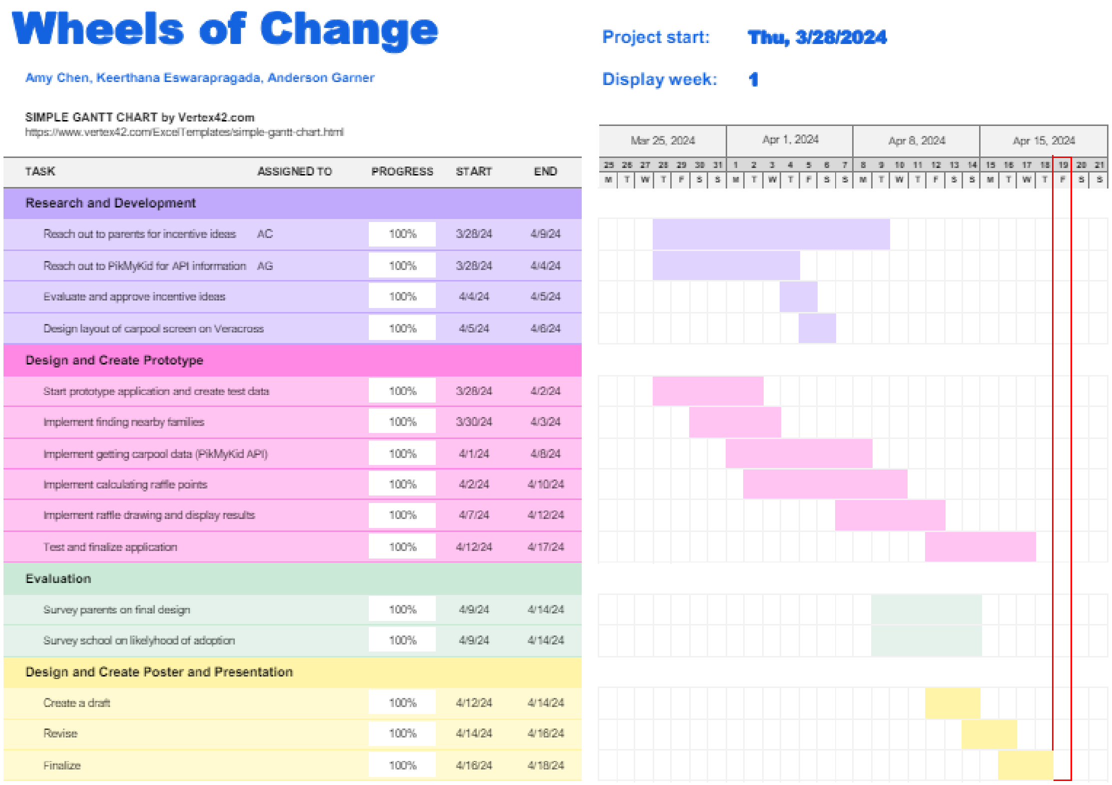


Figure 6: Actual Project Workflow Gantt Chart

The major differences between the planned and actual project workflow can be found in the prototype creation. We were hoping to complete the prototype well before the evaluation phase, but we instead had to evaluate the mostly completed but not finalized prototype application.

We underestimated the amount of time required to learn the tools and create working scripts, especially because of the constraint of proper error detection. Additionally, some bugs were discovered later than anticipated, as they were the result of integration of the python scripts with the main application. The debugging process was also not given a realistic amount of time in the planning phase.

Another minor difference was reaching out to parents. Our feedback came mostly from Professor Starling, and other parents not affiliated with STAB. We repeatedly came back for more information than initially expected as it became useful, and this continued to occur after the expected finishing date.

5.3 Reflection of Final Solution fulfilling Customer Needs

In this project, it was identified that the needs of the client mainly relate to reducing traffic time for parents while they are picking up their children. In addition, STAB prioritizes having a cost-effective solution. As a result, we came up with Wheels of Change, a solution that meets the requirements of being low-cost, and a direct path to reducing traffic wait times. Some constraints we faced while working on this project was the lack of a budget from the school. Fortunately, we were able to work around this by requiring materials for this project. Rather, it was mainly focused on creating a systems solution that would be able to prove our solution would be effective. Overall, the solution meets our objectives of a good user experience. This was concluded by our testing results and surveying some parents and users of the UI. Furthermore, it will meet our objectives of reducing congestion in the area by reducing the number of cars at the school. Although we were not able to directly test this and prove this, it is reasonable to conclude given that our testing results proved that parents would be interested in taking part in the carpool system.

6. RECOMMENDATIONS AND FUTURE WORK

6.1 Recommendations

There are several recommendations that we believe will improve our design.

A pilot program would greatly reduce the uncertainty with the program. One major drawback of the project was that we were unable to receive parent feedback. Ultimately, the goal of reducing traffic is to make the users of the system happy. Since we were unable to gather direct feedback from STAB parents, we are not certain as to whether parents would be willing to carpool. A pilot program, which focuses on bringing around randomized 10 parents into the program, would determine what portions of the project could be improved and what portions of the project could be helpful. A pilot program would likely be one to two weeks long, and measure if parents are willing to carpool for a small prize. While this pilot program would most likely not reduce waiting time as the sample size is too small, it would provide a good benchmark as to how many parents would carpool.

Another recommendation would be to contact STAB's IT department. Due to time constraints, we were not able to contact the IT department, so we coded the pseudo-software isolated from potential IT feedback. For example, we did not know exactly how STAB's database worked, thus, we decided that the database would be able to hold all the student's carpooling data with the assumption that the database was large enough. These assumptions may not be true, thus, contacting the IT department would be a good first step to determine if editing the software is feasible.

Lastly, using simulation software, such as AnyLogic or PTV Vissim, would help determine the minimum number of carpoolers necessary to significantly reduce wait times. While we considered using simulation software, our lack of knowledge with simulation software and the complexity of STAB's carpool routes made us consider alternative measures of success. Furthermore, since our solution focused on carpool incentives, we would need a ball-park figure as to the percentage of households willing to carpool. Since we were unable to gather data from parents, a simulation software would still not be able to determine if our solution was effective or not.

6.2 Future Work

Our solution could be easily paired with other carpooling solutions, as our solution is cheap and customizable. For example, many carpool solutions focused on adjusting the route itself; changing how the cars move to reduce bottlenecking at the end. Implementing a carpool incentive program and adjusting the carpool route are both feasible at the same time. Since the number of parents that carpool will likely not exceed a significant margin, our solution alone is unlikely to solve all the traffic issues during pick-up. However, it is a good first step to minimize the number of cars along the carpool route.

A survey should also be sent to parents to determine the interest of a potential carpool program. Specifically, the survey should focus on the raffle prizes ideas and opinions on the raffle entry rules. Interest forms for new programs are essential to determine both short-term and long-term interest in these programs. If enough parents show interest in a carpool incentives program, many more parents may catch onto the idea, which will increase the overall interest in the program.

Overall, future work should focus on receiving more STAB parent feedback and simulating the results on a simulation software. With these added changes, the solution could be better catered towards the client's needs and goals.

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Appendix A. Client Interviews

Client Interview with Autumn Graves and Pete Cormons

The client interview was conducted in-person. Principal Autumn Graves of STAB explained the traffic issue using a Powerpoint presentation. While we were unable to record the meeting, our notes from the meeting in addition to our questions are detailed below.

Client: Autumn Graves (Head of School) and Pete Cormons (Director of Facilities)

- What are some ideas that you are considering implementing?
- What have you considered/tried till this point that has been unsuccessful?
- Is your student body growing? Will this issue get worse or is it relatively constant? (Establishes scale of solution.)
- What is the general timeline for implementing the solution? Are you looking for more of a long term or short term solution or both?
- What is your current transportation like? (what are the various ways students get home?)
- How many parents are picking up multiple siblings? Is there a process in place to unite siblings so that they can get to their car faster?
- Should preschoolers be considered? How is that system like currently?
- Should we address the after-school or sports pickup?
- How viable would a shuttle system be? Can we utilize buses to drop students off at a secondary location?
- Do parents like using the app to check in?
- How often do other factors, such as maintenance, exacerbate traffic conditions? As a rough estimate, how much do these factors increase the overall wait time for parents?

Meeting Notes and Summary:

Organized notes:

Current state:

- Use of app: picmykid
    - Nice things: able to delegate carpools to help with transportation

        - Cons: all cars don't have the booster seats and necessary "stuff" for students, people also do not know about the carpool feature and might not utilize.

VDOT project pipeline

Dismissal times:

- 3:10 is peak traffic time
- Lower: 3:15
- Middle: 3:35 and middle 2: 4:10
    - On fridays: 7/8 get out at 3:35
        - Friday dismissal is worse
- Highschool: 3:30 dismissal
    - On fridays: 2:45

Sports:
JV - 5:45-6
Middle: 2:50-4 pm

- 7/8 2:45 for sports dismissal
- "What is the most popular season"
- Fall is most busy