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Student Success and Evaluation Metrics

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Student Success and Evaluation Metrics The Blue Barred

ISYE 4900 - Senior Design

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Abstract

In so many instances, students drift through high school and are unaware of what types of job opportunities are out there for them. It is easy to see that a student can get overwhelmed by the number of career options, or they may not know what they want to do at all. The Blue Barred has generated a solution that allows students to see their options much more clearly through the analysis of six factors and their contribution to success: Engagement, Value Added Learning, Network-ability, Literacy, Numeracy, and Graduation Rates. Through the usage of tools such as literary research, surveys, the House of Quality, a Pareto chart, and a Lingo code-based Optimization model, we were able to discover that amongst the defined six factors that contribute to maximizing the number of career opportunities, the student who sees the value in what they learn in school will have a much wider array of job opportunities from which to select. This also shows that schools should focus the most on value added learning to produce the most successful students.

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Chapter 1: Preface

1.1: Introduction

South Korea, Japan, and Europe have higher graduation rates, and they do a better job of integrating their students into the adult world. This results in an optimal number of successful students, and as a result, the students are able to find careers they want to pursue. GCPS is the largest school system in Georgia, and they have a more diverse student populace than foreign schools. GCPS schools differ from foreign schools in that students have more options to choose from for which classes they want to take; however, there is no way for them to match any of their strengths to corresponding careers. This problem affects GCPS students, for each student has a different skill set and does not know what is the optimal amount of each skill to get a job. The Blue Barred seeks to solve this issue by maximizing student opportunity through the usage, definition, and analysis of the six different characteristics.

1.2: Overview

Gwinnett County Public Schools' (GCPS) current model of student success is to orient students towards college or career preparation. However, GCPS does not consider each student's skill set despite having a strong relationship with the number of opportunities being available for the student. This can lead students to not know the opportunities available to them as well as cause students to enter a job sector that is not suitable for them. Of course, this leads to students losing out on valuable time and possibly money. The Blue Barred has decided to define the maximum number of opportunities as the measure for student success; students should have their skill set measured and then be shown the maximum number of opportunities available to them based on their skills.

1.3: Objective

- Create a model that maximizes job opportunities via student's skill sets
- Determine what skills GCPS are falling behind in.
- Recommend improvements on skills that GCPS is lacking.

1.4: Major Justifications

Preparing students for college and the workforce should be a priority for GCPS schools. If students know what they want to do after high school as well as what opportunities correspond with their skills, then there is a higher probability the students may feel more confident about the decisions they make and what they can achieve. This can lead to students spending less time and money on figuring out which field is appropriate for them. In addition, the GCPS schools and the labor force benefit from this project as well. GCPS would benefit by having their reputations enhanced, and the labor force would benefit by having access to workers with the skills the employers desire.

1.5: Project Background

GCPS teaches a strict set of core subjects. They are social studies, sciences, mathematics, and language arts. GCPS also gives students choices in a set of classes that can augment their experience. These electives are chosen based on certain criteria. An example would be a language [Spanish, French, German] class that must be taken, or a music class such as band. These are meant to drive students' interest. There is an issue with there being a lack of utility in matching students to a skillset insofar as making students comfortable with their decisions in the future. This takes the form of changing majors [in college], poor workforce morale, and a workforce who is disillusioned in the prospect of a successful future. The blue barred plans to maximize the opportunities available to high school students so that they can be more equipped to handle the issues that will come with becoming adults.

1.6: Problem Statement

GCPS high schools have the largest student body at approximately 177,401 students. The average graduation rate is 86% [18] with no clear measures of spread. With a student-faculty ratio of 15:1; teachers are unable to maximize an individual student's success due to grading requirements, the reevaluation of courses, and the teaching environment itself. The Blue Barred plans to alleviate this issue through the use of two major tools: an optimization model and a pareto distribution. To support these two, a house of quality and qualitative survey will be produced to confirm any assumptions made in the process.

Chapter 2: Literary Review

2.1: The Six Metrics of Success

Success has always been a difficult task to define as it is defined proportionally to the reference point. The standard definition of success is “the accomplishment of an aim or purpose”. This definition only goes so far since this definition is subjective in nature. Bringing a measure to this relies on our understanding of what schools want for students to be successful. One consensus believes a school should focus on cultural changes to get the optimal results [19]. Although culture in schools should be altered to accommodate the misfortunes of students; the question is what metrics define the appropriate amount of aid given? What aid benefits each student in the long run? Since we have an obligation to students to tell the truth, what gives students the most opportunity to succeed? The next section discusses factors that can be used to measure all the questions listed above.

2.1.1: Engagement

Engagement is the willingness of persons to participate in an activity. In the context of this report, it is a student’s willingness to participate in classes, extracurricular activities, and the community. An example of things not included would be hanging out with friends although creating friends can be an outcome of engagement.

Motivation has a strong effect on engagement. Students have a range of motivations and parent involvement is one such instance. According to one study, when parents are involved in a student’s academics, the student has a higher level of success in school overall [9]. In particular, parent rules on television and their aspirations for post-secondary education was noted to have the biggest effect. However, the opposite is true in cases where the school is contacting parents for behavioral reasons and when parents set grade-based expectations on their children.

Another measure of engagement comes from teacher competency and communication ability. There is a positive correlation between students’ perceptions about teachers and their motivations in learning [1]. Although this correlation is weak, most schools are attempting to increase communications between students and their teachers [2]. We speculate this could improve the correlation as a product of interest. Hands-on activities have a higher impact on interest in learning environments than conceptual learning (i.e.: reading a textbook). As a result, another series of questions were made as a consequence of these findings. The goal is to verify the research found.

2.1.2: Value Added Learning

Of the factors used to measure success, this is the most obscure. “Value Added Learning” (VaL) is defined as the ability of students to understand the value of what they have learned or are currently learning. The obscurity comes from what defines value. The Blue Barred assumed value is: *the regard that something is held to deserve or the importance, worth, or usefulness of something*. VaL as a factor benefits students by not only allowing students to apply what they learned, but this factor also helps students learn by giving them a reason to apply what they learned. The question, “*When will I use this?*”, should come to mind when thinking of this factor. UCLA attempted to measure this by introducing high school students to a research program with the goal of giving students a college experience without the risks of going firsthand [8]. The study found that students experienced mostly positive experiences during the program and considered enrolling in a STEM program at UCLA as a result. This could be due to recognizing how STEM fields produce value externally or an increase in intrinsic value for the recipient.

The University of Tulsa (TU) produced a study that showed that 80% of students currently in college are expected to or have changed their major [3]. The conclusion is that this is a good thing for students because the students are able to try new things. This does come at a cost in time, money, and effort. Students generally go to university to get a career, and deviations take away from the goal. It is more advantageous for students to know what they want to do beforehand, for now, this prevents them wasting time, money, and effort. The study begs the question, “Why do students change majors?” The team hypothesizes this is because the student either did not want the workload or was not enjoying what they were doing; both reasons reflect having reduced intrinsic value towards the subject matter.

The last study relevant to VaL is the study regarding mathematical learning ability [1]. Connectional ability or connecting the work to the real-world improved learning achievement and problem-solving ability.

2.1.3: Network-Ability

This is the third factor affecting student success that we wanted to measure. We defined networking as the ability to communicate with others; this can include coworkers, employers, and other colleges. Currently, a lack of this factor has been causing students to misunderstand things like attendance and grading policy [7]. This can be detrimental to student success.

GCPS also has no ways of connecting students to colleges and employers. This causes a decrease in network-ability. In countries like Japan, however, employers and schools work together to help students find a job [15]. The results of our model could help schools improve this aspect of a student’s skill set. It would match the student to an industry that meets a student’s rating of the six factors. As a result, students are linked with possible employers or helping them decide what they want to do in college.

2.1.4: Literacy and Numeracy

Literacy is the ability to read and write while numeracy is the ability to understand and work with numbers. In the U.S., the average numeracy rate is 70% [4], and the literacy rate was 79% [5]. With these high numbers, it may seem as if these two factors may be the least important to our project. However, there is a study that found that employers value literacy, numeracy, and punctuality the most from their employees [15]. This finding adds more weight to the literacy and numeracy factors when it comes to measuring each student's number of opportunities. It also means that the researchers will need to find which job sector has the highest ranking for literacy and numeracy.

2.1.5: Graduation Rates

The last factor is graduation rates or essentially how many students graduate from high school. This may be our weakest factor because in GCPS the graduation rate is about 83.625% [14]. However, this is less than the overall U.S. graduation rate of 86% [10]. Graduation rates are still important to the project, for there are industries that value graduation from high school on a higher level. Graduation rates not only affect the number of opportunities from the job sector but also affect whether a student goes to college. Even though GCPS has a high graduation rate, it is still important to measure its effect on student success.

2.2: Surveys for Data Collection.

Surveys or polls have been used for a long time as a statistical tool. Surveys are a reliable way to collect data when other means are unavailable. Surveys get direct responses from the subject population to make an educated guess of the opinions on a particular topic. The four main reasons to conduct a survey are: 1) surveys provide hard numbers on what people believe, 2) benchmarking is available for those who want to use it to make decisions, 3) several "why" factors are available through explicit data, and 4) survey gives a voice to the people taking the survey [17]. Surveys have the benefit of being used as an add-on for other statistical tools such as spreadsheet software, Ishikawa diagrams, and Houses of Quality.

2.3: House of Quality

The House of Quality (HoQ) translates qualitative data from the customers to quantitative data for the engineers. The HoQ can be difficult to construct because customers have many dimensions to quality, and it is impossible to satisfy every requirement. However, this tool is very useful in that it reduces pre-launch time and post-launch tinkering [20].

2.4: Pareto Chart

One reason the Pareto Chart is unique is because it uses a special rule to determine which factors contribute the most to a common entity. This special rule is known as the 80/20 rule, and this rule will show that 20% of the factors cause 80% of the problems. However, from an intuitive standpoint, solving the issues present in a Pareto chart could result in increased productivity [21].

2.5: Lingo and product-mix optimizations

Lingo is a software tool meant to build and solve a series of optimization problems [22]. Some of these problems include linear and nonlinear programming, quadratic, and stochastic models. From the Lindo package, this tool is an efficient solver using summation and subscript variables. This means coding is as simple as using paper and pencil with the computational power of any CPU.

Another major feature of the model is it can incorporate data from other software and has callable DLL and OLE interfaces for turn-key solutions. This lets Lingo solve issues already made without any re-coding necessary.

2.6: Industry sectors

The definition of a sector in business is defined as a large segment of the economy [24]. Reports on markets suggest that America has 18 sectors [25]. Each is divided by a unique set of traits that make them an integral part of society. Without a sector, there is a set of issues in the market that would not be solved. This can include environmental issues such as waste management or housing for the population from the construction sector. To increase the workforce, the youth enter the workforce, and they are divided by the type of labor they produce.

Public services such as the Bureau of Labor Statistics (BLS) accumulate data on the sectors [23]. The data can be used by investors who want to branch out, government officials who want to influence policy, or new hires trying to get into the market.

Chapter 3: Methodology

3.1: Approach

1. The objective is to determine which decision variable(s) have the highest impact of producing a successful student; the successful student is the student with as many job opportunities as possible. The Blue Barred will use information to determine student success through the number of job opportunities they are able to receive. Through the usage of input from students and prior research, the Blue Barred will determine student success with following results:
 - a. An algorithm that produces the maximum number of opportunities per student
 - b. A model that validates the optimization
 - c. Student responses to survey
 - d. Possible recommendations for GCPS

2. Variables

The six **decision variables** of success (x)

- i. Engagement
 - ii. Value added learning
 - iii. Graduation rate
 - iv. Literacy
 - v. Numeracy
 - vi. Network-ability
- a. Job Sectors (y)
 1. Education
 2. Agriculture/ Forestry
 3. Utilities
 4. Mining
 5. Accommodations / Food services
 6. Art, Education, and Recreation
 7. Transportation
 8. Administration, Business, and Waste
 9. Other (except Public Administration)
 10. Finance/Insurance
 11. Real Estate, Rental, or Leasing
 12. Healthcare, Social Assistance
 13. Manufacturing
 14. Construction
 15. Professionalism, Science, Tech

- 16. Information
- 17. Retail Trade
- 18. Wholesale Trade

3. The survey the team created is to gain student input about GCPS schools and how the six decision variables affect the students. The questions on the survey are mostly closed-ended with only one open-ended question. The closed ended questions are a mixture of multiple-choice questions, and Likert scale questions. Each question was sorted by which decision variable(s) they represent, and they were assigned a score.

4. Blue Barred used Microsoft Excel to rank the decision variables in relation to each job sector. If a job sector had a number 1 beside a decision variable, this means the decision variable would be the least important to that sector. Then, the average decision variable scores were derived from these rankings.

5. The survey data would be plugged into a HoQ in order to derive quantitative data that could be used to validate the optimization model. This would also be used to create a Pareto chart to determine which decision variable(s) the school is lacking in as well as to confirm the accuracy of the optimization model.

6. The optimization model was created to determine the maximum number of opportunities a school could generate per student in relation to the six major decision variables.

To determine the decision variable with the most usefulness, we used a product-mix optimization problem. The following are the dimensions of the model:

$$1) \text{ Max} = \sum_{p=0}^{inf} \sum_{i=1}^{18} (c_p y_i) ; \text{ where } c_p \text{ is the opportunities associated with a } y_i \text{ sector}$$

2) St:

a) $\sum_{i=1}^6 X_i = 1$; where $X_i = \{E, V, G, Nu, L, Ne\}$ are the 6 decision variables we compare each sector against.

i) E = Engagement

ii) V = Value added Learning

iii) G = Graduation rate

iv) Nu = Numeracy

v) L = Literacy

vi) Ne = Network-ability

b) $E > 0.01$;

c) $V > 0.01$;

d) $G > 0.01$;

e) $Nu > 0.01$;

f) $L > 0.01$;

g) $Ne > 0.01$;

i) This is to assure all assigned factors have a minimum 1% inclusion.

h) $\sum_{i=1}^{18} (c_i y_i) \leq 718$; Capacity of opportunities is 718.

i) $\sum_{j=0}^1 \sum_{i=1}^6 (c_j x_i) \geq S y_i$; where S is the score associated with achieving opportunities in sector y_i and C_j is the scaled score of the factor x_i .

$$i) S = \left(\sum_{i=1}^6 \left[\frac{\text{Ranked score } X_i \text{ for sector } y}{\text{Average score } X_i \text{ for sector } y} \right] \right) * \left(\frac{C_p}{718} \right)$$

j) @BINARY(all(y_i)); we either have the opportunities or not,

Figure 1: Product-mix optimization for 6 factors for opportunity generation

3.2: System Requirements

- The Blue Barred will determine the maximum number of job opportunities for students based on the levels of each of the six factors they have.
- The Blue Barred will survey the students to determine their levels of each of the six metrics.
- The Blue Barred will determine which sector needs which amount of the six factors in order to find the best employees.
- The Blue Barred will determine average class size of GCPS schools
- The Blue Barred will convert qualitative data from surveys to quantitative data for the optimization model

3.3: Gantt Chart

Figure 2 is the Gantt chart that shows how the project was scheduled. It shows how the work was divided and when it will be completed. Although most of the work the Blue Barred conducted involved all members of the group, the schedule represented by the Gantt chart changed when unexpected events occurred or when analyzing the data took longer than usual.

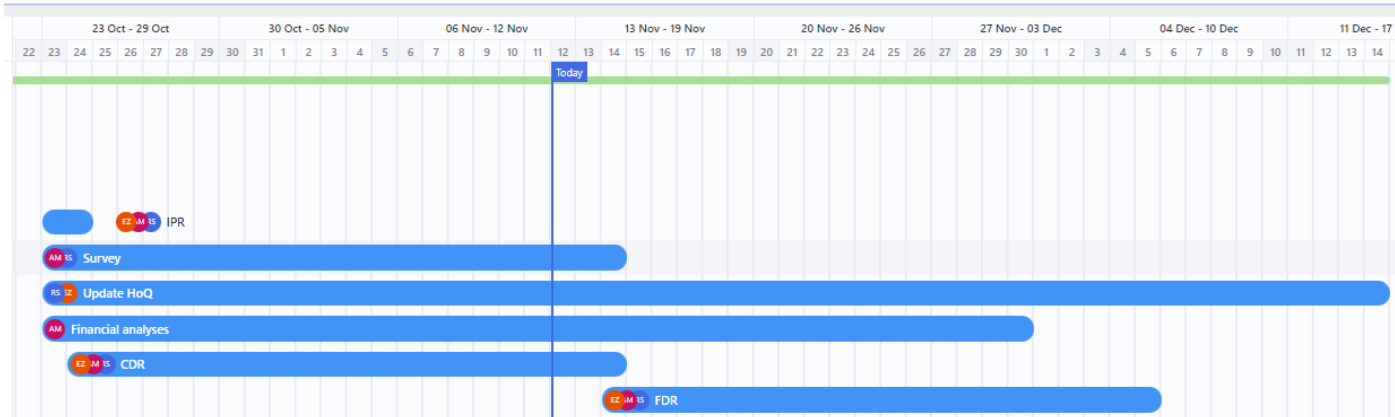


Figure 2: Gantt Chart

3.4: Flow Chart and Block Chart

The flowchart in Figure 3 visually demonstrates how students traverse their high school career, and it displays a list of general options available for them after they leave.

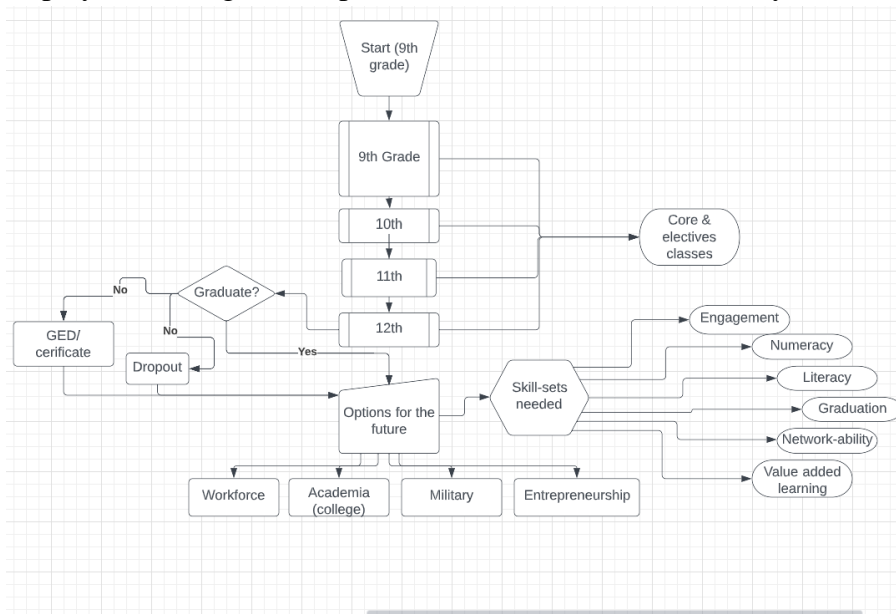


Figure 3: Flow Chart

The process block diagram in Figure 4 below shows how the team went about solving the issue.

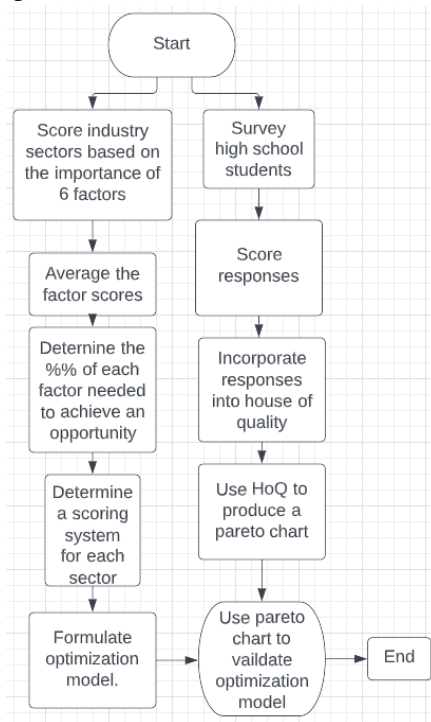


Figure 4: Block Chart

3.5: Project Management

First, the literary research was conducted because the researchers knew this was going to be the backbone of the project. As so, the authors agreed to research an equal number of articles to make the research easier to conduct.

In addition, the researchers knew that data from the students would prove invaluable; however, the process for getting the access to the students has not been as yielding. So, the researchers consulted a professor about this issue, and it was revealed that proxy data could still be useful as a temporary substitution for the real data the authors were anticipating.

The researchers created questions that were geared to measure the six characteristics qualitatively, and with this data, we created the HoQ. As for the optimization model, the researchers received some professional guidance in order to make sure the model was formulated correctly. We met with at least one professional once a week in order to achieve this goal.

3.6: Responsibilities

As Project Manager, Ricky applied his technical expertise in formulating the model using Optimization skills. In addition, the project manager guides the researchers into the work as well as aiding them in staying focused on the primary goals of the project.

As Lead Researcher, Elena synthesized the data collected by the authors and grouped the research findings through the perspectives of the articles. This allowed the researchers to support the claims that the six characteristics discussed earlier in the report do contribute to success.

As Meeting Coordinator, Andrew was primarily responsible for scheduling the meetings with the outside assistance for professional guidance with the project. The meeting coordinator also provided additional assistance to the Lead Researcher.

3.7: Budget

The budget for this project was designed using data from the average salaries of the industry they worked in. The Blue Barred also assigned a 4% sales tax on the work performed. Software, hardware, and survey costs were not taken into account in the industry; those costs are put into the price of service. The total amount of the work that would be accumulated would come to \$76,734.32. This is shown in **Figure 5** below:

	Economic Analysis			
Names:	Ricky Singletary	Andrew Morgan	Elena Van Zanten	Total
Title:	Project Manager	Engineering coordinator	Senior Research associate	
Annual salary	\$91,578	\$57,153	\$72,618	\$221,349
Time worked	4 months			
Monthly salary	\$7,631.50	\$4,762.75	\$6,051.50	\$18,445.75
Pay for period (\$)	\$30,526.00	\$19,051.00	\$24,206.00	\$73,783.00
Sales taxes %%	0.04	0.04	0.04	\$0.04
Sales taxes	\$1,221.04	\$762.04	\$968.24	\$2,951.32
Total Revenue	\$31,747.04	\$19,813.04	\$25,174.24	\$76,734.32

Figure 5: Estimated budget

3.8: Material Required

This section lists what materials were used during the duration of the project:

- Paper (Used for surveys)

3.9: Resources Available

The following is a list of the resources used during the project.

- Microsoft Excel
- Microsoft Teams
- Google Docs
- Google Slides
- Google Forms
- Lingo/Lindo
- GroupMe
- Advisors (see Appendices)

Chapter 4: Collect

4.1: Survey Data

In order to produce an optimization model that could be validated, the first step was to produce a method to validate it. The approach taken was to use the survey questions in Figure 6.

- S2S student survey
- 1) What grade are you in?
 - a) 9th
 - b) 10th
 - c) 11th
 - d) 12th
 - 2) I will use what I learned in class in the last 3 months:
Strongly Agree, Agree, neutral, Disagree, Strongly Disagree
 - 3) Which Core subject has the least impact on your day to day?
 - a) Math
 - b) Sciences
 - c) History
 - d) Language arts
 - 4) Which Core subject has the most impact on your day to day?
 - a) Math
 - b) Sciences
 - c) History
 - d) Language arts
 - 5) I plan to ___ after school:
 - a) Get a job
 - b) College/trade school/apprenticeship
 - c) Military
 - d) IDK
 - e) Other (Please fill in) _____
 - 6) Do you have a job?
 - a) Yes
 - b) No
 - c) Prefer not to answer
 - 7) I am confident about the future:
Strongly Agree, Agree, neutral, Disagree, Strongly Disagree
 - 8) My classes helped me determine what career path I would like to pursue?
Strongly Agree, Agree, neutral, Disagree, Strongly Disagree
 - 9) Do you participate in extracurricular activities?
 - a) Yes
 - b) No
 - c) Unsure
 - d) Prefer not to answer
 - 10) Which Core subject are you most proficient at?
 - a) Math
 - b) Sciences
 - c) History
 - d) Language arts
 - 11) My school reveals opportunities that I have after my high school career.
Strongly Agree, Agree, neutral, Disagree, Strongly Disagree
- S2S student survey
- 12) How active are your parents in your school life?
 - a) Every day/week
 - b) Once a month
 - c) Once a semester
 - d) Never
 - 13) How often does the school contact your family?
 - a) Very often
 - b) Sometimes
 - c) Never
 - 14) How would you improve the school experience?

 - 15) I take electives mostly for:
 - a) Fun
 - b) Career exploration
 - c) Credits to graduate
 - d) Skills acquired
 - 16) I took higher level (ap,ib) core classes primarily to / for:
 - a) College credit
 - b) Bragging rights
 - c) Knowledge sake
 - d) I didn't (n/a)
 - e) Other (please fill) _____
 - 17) What I enjoy about my classes are:
 - a) The coursework
 - b) The friends I make
 - c) A fun teacher
 - d) Other (please fill) _____
 - 18) My teachers ask their students to participate in class
Strongly Agree, Agree, neutral, Disagree, Strongly Disagree
 - 19) Without my classes/School I can still make a living:
Strongly Agree, Agree, neutral, Disagree, Strongly Disagree
 - 20) I learn best when:
 - a) I talk to others about the topic
 - b) I do activities that are related to the topic
 - c) I read about it
 - d) Other (please fill in) _____
 - 21) Group work is necessary for success:
Strongly Agree, Agree, neutral, Disagree, Strongly Disagree

Figure 6: List of Survey Questions

Each question has a distinct variable that is referenced and responses that correlate to a score. For the free-response questions, the purpose is to determine how invested a student is in

the survey and to reveal anything that would adjust our assumptions on the scoring system as well as reveal what ways they believe a school can improve.

4.1.1: Student Voice & HoQ

Student voice data is derived from the survey given to students. Each question was created based on the research and then, it was sorted into what factor that question was trying to measure. This data will then be plugged into a HoQ. In addition, this tool will translate the qualitative data from the surveys into quantitative data for the Pareto chart. The HoQ also represents the relative strength of each factor. The data that is obtained from the usage of this tool will be used to create a Pareto chart to determine which factor GCPS schools need to improve the most.

The Blue Barred will then compare this data to the optimization model to figure out which factor has the biggest impact on student success and propose a recommendation on which factors a school should improve.

4.1.2: Sector Voice

The sector voice represents the voice of the employer. The researchers completed this part of the data via several assumptions. The primary assumption is each variable is segregated by importance. This means an initial score of six is more important than a score of five; however, the actual difference in importance is uncertain. The second assumption is how those scores were calculated. For the purposes of this assignment, the team deemed it more practical to base those scores on work experience instead of concrete data on the topic. This is for two reasons. The first reason revolves around the time that is allotted for this project as collecting concrete data would be beyond the scope of our project. The second is because the data may become obsolete in the future. This assumption allows future researchers to adjust our primary table to achieve a more accurate result.

4.2: Creating the Industry Scores

The scores for the industries were created by ranking the factors (6 meaning it had the strongest impact to the industry; 1 meaning it had the least) for each industry.

Then, each column of each decision variable was averaged. After the average for each column is calculated, the researchers took each score for each characteristic and divided them by the column average. This is shown in table 1&2.

Ranked table							
Industry name	Eng score	Val score	Grad score	Num score	Lit score	Net score	Total jobs
Educational services	4	6	5	1	2	3	14
Agriculture, Forestry...	6	5	1	3	2	4	30
Utilities	5	2	4	6	1	3	11
Mining	6	4	1	2	3	5	11
Accomodations/ food..	3	2	1	5	4	6	15
Art, Edu, & recreation	6	3	2	1	4	5	20
Transportation	5	2	1	4	3	6	38
Admin, bus, and waste	2	1	3	4	5	6	26
Other (except public admin)	4	5	1	2	3	6	29
Finance/insurance	2	1	4	6	5	3	32
Real estate/ rental/ leasing	3	1	2	4	5	6	20
Healthcare, social assistance	3	6	4	1	2	5	34
Manufacturing	6	1	2	5	4	3	194
Construction	6	2	1	3	4	5	37
Professionalism science, tech	3	2	1	6	5	4	36
Information	1	2	3	5	6	4	39
Retail trade	3	2	1	4	5	6	64
Wholesale trade	2	3	1	4	5	6	68
	3.88889	2.77778	2.11111	3.66667	3.77778	4.77778	718

Weight scores								
Industry name	Eng score	Val score	Grad score	Num score	Lit score	Net score	Total jobs	
Educational services	1.03	2.16	2.37	0.27	0.53	0.63	14	6.99
Agriculture, Forestry...	1.54	1.80	0.47	0.82	0.53	0.84	30	6.00
Utilities	1.29	0.72	1.89	1.64	0.26	0.63	11	6.43
Mining	1.54	1.44	0.47	0.55	0.79	1.05	11	5.84
Accomodations/ food..	0.77	0.72	0.47	1.36	1.06	1.26	15	5.64
Art, Edu, & recreation	1.54	1.08	0.95	0.27	1.06	1.05	20	5.95
Transportation	1.29	0.72	0.47	1.09	0.79	1.26	38	5.62
Admin, bus, and waste	0.51	0.36	1.42	1.09	1.32	1.26	26	5.97
Other (except public admin)	1.03	1.80	0.47	0.55	0.79	1.26	29	5.90
Finance/insurance	0.51	0.36	1.89	1.64	1.32	0.63	32	6.36
Real estate/ rental/ leasing	0.77	0.36	0.95	1.09	1.32	1.26	20	5.75
Healthcare, social assistance	0.77	2.16	1.89	0.27	0.53	1.05	34	6.67
Manufacturing	1.54	0.36	0.95	1.36	1.06	0.63	194	5.90
Construction	1.54	0.72	0.47	0.82	1.06	1.05	37	5.66
Professionalism science, tech	0.77	0.72	0.47	1.64	1.32	0.84	36	5.76
Information	0.26	0.72	1.42	1.36	1.59	0.84	39	6.19
Retail trade	0.77	0.72	0.47	1.09	1.32	1.26	64	5.64
Wholesale trade	0.51	1.08	0.47	1.09	1.32	1.26	68	5.74
							718	

Table 1 & 2: Initial Rank and Weight Tables

This fraction is then multiplied by the ratio between the number of the industries in a specific sector over the total number of jobs available. This final product represents the score one needs to get into that specific job sector. This is signified by the value S in section 3.1 or table 3.

Right Scores table									
Industry name	Eng score	Val score	Grad score	Num score	Lit score	Net score	Total jobs	% of total jobs	Total Score (\$)
Educational services	0.0201	0.0421	0.0462	0.0053	0.0103	0.0122	14	0.0195	0.1362
Agriculture, Forestry...	0.0645	0.0752	0.0198	0.0342	0.0221	0.0350	30	0.0418	0.2508
Utilities	0.0197	0.0110	0.0290	0.0251	0.0041	0.0096	11	0.0153	0.0985
Mining	0.0236	0.0221	0.0073	0.0084	0.0122	0.0160	11	0.0153	0.0895
Accomodations/ food..	0.0161	0.0150	0.0099	0.0285	0.0221	0.0262	15	0.0209	0.1179
Art, Edu, & recreation	0.0430	0.0301	0.0264	0.0076	0.0295	0.0292	20	0.0279	0.1657
Transportation	0.0680	0.0381	0.0251	0.0577	0.0420	0.0665	38	0.0529	0.2974
Admin, bus, and waste	0.0186	0.0130	0.0515	0.0395	0.0479	0.0455	26	0.0362	0.2160
Other (except public admin)	0.0415	0.0727	0.0191	0.0220	0.0321	0.0507	29	0.0404	0.2382
Finance/insurance	0.0229	0.0160	0.0844	0.0729	0.0590	0.0280	32	0.0446	0.2833
Real estate/ rental/ leasing	0.0215	0.0100	0.0264	0.0304	0.0369	0.0350	20	0.0279	0.1601
Healthcare, social assistance	0.0365	0.1023	0.0897	0.0129	0.0251	0.0496	34	0.0474	0.3161
Manufacturing	0.4169	0.0973	0.2560	0.3684	0.2861	0.1697	194	0.2702	1.5943
Construction	0.0795	0.0371	0.0244	0.0422	0.0546	0.0539	37	0.0515	0.2917
Professionalism science, tech	0.0387	0.0361	0.0238	0.0820	0.0664	0.0420	36	0.0501	0.2889
Information	0.0140	0.0391	0.0772	0.0741	0.0863	0.0455	39	0.0543	0.3361
Retail trade	0.0688	0.0642	0.0422	0.0972	0.1180	0.1119	64	0.0891	0.5023
Wholesale trade	0.0487	0.1023	0.0449	0.1033	0.1253	0.1189	68	0.0947	0.5435
							718	1.00	

Table 3: S-Score Table

Summing the sector weights and averaging the individual scores gives us table 4: the relative weights of the variables relative to each other.

Left scored Table									
Industry name	Eng score	Val score	Grad score	Num score	Lit score	Net score	Total jobs		
Educational services	0.15	0.31	0.34	0.04	0.08	0.09	14	1.00	0.0195
Agriculture, Forestry...	0.26	0.30	0.08	0.14	0.09	0.14	30	1.00	0.0418
Utilities	0.20	0.11	0.29	0.25	0.04	0.10	11	1.00	0.0153
Mining	0.26	0.25	0.08	0.09	0.14	0.18	11	1.00	0.0153
Accomodations/ food..	0.14	0.13	0.08	0.24	0.19	0.22	15	1.00	0.0209
Art, Edu, & recreation	0.26	0.18	0.16	0.05	0.18	0.18	20	1.00	0.0279
Transportation	0.23	0.13	0.08	0.19	0.14	0.22	38	1.00	0.0529
Admin, bus, and waste	0.09	0.06	0.24	0.18	0.22	0.21	26	1.00	0.0362
Other (except public admin)	0.17	0.31	0.08	0.09	0.13	0.21	29	1.00	0.0404
Finance/insurance	0.08	0.06	0.30	0.26	0.21	0.10	32	1.00	0.0446
Real estate/ rental/ leasing	0.13	0.06	0.16	0.19	0.23	0.22	20	1.00	0.0279
Healthcare, social assistance	0.12	0.32	0.28	0.04	0.08	0.16	34	1.00	0.0474
Manufacturing	0.26	0.06	0.16	0.23	0.18	0.11	194	1.00	0.2702
Construction	0.27	0.13	0.08	0.14	0.19	0.18	37	1.00	0.0515
Professionalism science, tech	0.13	0.12	0.08	0.28	0.23	0.15	36	1.00	0.0501
Information	0.04	0.12	0.23	0.22	0.26	0.14	39	1.00	0.0543
Retail trade	0.14	0.13	0.08	0.19	0.23	0.22	64	1.00	0.0891
Wholesale trade	0.09	0.19	0.08	0.19	0.23	0.22	68	1.00	0.0947

Table 4: Relative Weight per Sector Table

4.2.1: How the Model Works

The objective function of the model is represented by expressing the total number of jobs per sector. Each job sector was represented as a binary in order to reflect that the student either is qualified for all jobs in a specific sector, or they are not qualified. The number zero represents that the student did not attain the jobs in that sector while the number 1 indicates the student did attain all the jobs in that sector. The jobs obtained by the student were then totaled to determine the maximum opportunities each student received. The output also determined which of the six factors was important by determining which factor had the largest coefficient.

Chapter 5: Analysis

5.1: Model Data

The model shown in Figure 6 was optimized using Lingo, an optimization software. The code is given below in Figure 6.

```

Lingo 19.0 - [Lingo Model - Final optimization]
File Edit Solver Window Help
Max = 14*y1 + 30*y2 + 11*y3 + 11*y4 + 15*y5
+ 20*y6 + 38*y7 + 26*y8 + 29*y9
+ 32*y10 + 20*y11
+ 34*y12 + 194*y13 + 37*y14 + 36*y15
+ 39*y16 + 64*y17 + 68*y18;
!Scaled variable to S-scores;
.15*E + .31*V + .36*G + .04*Mu + .08*L + .09*Ne >= .1362*y1;
.26*E + .21*V + .09*G + .14*Mu + .09*L + .14*Ne >= .2503*y2;
.2*E + .21*V + .29*G + .25*Mu + .04*L + .1*Ne >= .0985*y3;
.26*E + .25*V + .08*G + .09*Mu + .14*L + .18*Ne >= .0985*y4;
.14*E + .13*V + .08*G + .24*Mu + .19*L + .22*Ne >= .1179*y5;
.26*E + .18*V + .16*G + .09*Mu + .18*L + .18*Ne >= .1657*y6;
.23*E + .13*V + .08*G + .19*Mu + .14*L + .22*Ne >= .2974*y7;
.09*E + .06*V + .24*G + .18*Mu + .22*L + .21*Ne >= .2160*y8;
.17*E + .31*V + .08*G + .09*Mu + .13*L + .21*Ne >= .2382*y9;
.08*E + .06*V + .30*G + .26*Mu + .21*L + .1*Ne >= .2833*y10;
.13*E + .06*V + .16*G + .19*Mu + .23*L + .22*Ne >= .1601*y11;
.12*E + .32*V + .28*G + .04*Mu + .08*L + .16*Ne >= .3161*y12;
.26*E + .06*V + .16*G + .23*Mu + .18*L + .11*Ne >= 1.5943*y13;
.27*E + .13*V + .08*G + .14*Mu + .19*L + .18*Ne >= .2917*y14;
.13*E + .12*V + .08*G + .28*Mu + .23*L + .15*Ne >= .2889*y15;
.04*E + .12*V + .23*G + .22*Mu + .26*L + .14*Ne >= .3961*y16;
.14*E + .13*V + .08*G + .19*Mu + .23*L + .22*Ne >= .5023*y17;
.09*E + .19*V + .08*G + .19*Mu + .23*L + .22*Ne >= .5435*y18;
!capacity constraint 718;
14*y1 + 30*y2 + 11*y3 + 11*y4 + 15*y5
+ 20*y6 + 38*y7 + 26*y8 + 29*y9
+ 32*y10 + 20*y11 +
34*y12 + 194*y13 + 37*y14 + 36*y15
+ 39*y16 + 64*y17 + 68*y18 <= 718;
!Factor constraint (a student is made up of these factors);
E + V + G + Mu + L + Ne = 1;
E > .01;
V > .01;
G > .01;
Mu > .01;
L > .01;
Ne > .01;
!manually put all binaries in;
@BIN(y1);
@BIN(y2);
@BIN(y3);
@BIN(y4);
@BIN(y5);
@BIN(y6);
@BIN(y7);
@BIN(y8);
@BIN(y9);
@BIN(y10);
@BIN(y11);
@BIN(y12);
@BIN(y13);
@BIN(y14);
@BIN(y15);
@BIN(y16);
@BIN(y17);
@BIN(y18);
    
```

Figure 7: Product-mix optimization code

The output of this model showed the decision variable that had the greatest impact on student success was *Value Added Learning* at 0.4487. This does not mean that the other factors made no impact. The list of the rest of the factors below are ranked from most important to least important:

2. Engagement = .33424
3. Network ability = .18707
4. Numeracy, Literacy, and Graduation = .1

The output below in Figure 7 showed that the maximum number of opportunities was 130 opportunities. This means that out of the 718 jobs available from all the sectors, the students could only get 130 jobs based on the six decision variables. The specific industries correspond to $y(i)$, where i = the name of the job sector {1-6, 9}.


```

Global optimal solution found.
Objective value:                130.0000
Objective bound:                130.0000
Infeasibilities:                0.000000
Extended solver steps:         104
Total solver iterations:       1862
Elapsed runtime seconds:       0.24

Model Class:                    MILP

Total variables:                24
Nonlinear variables:            0
Integer variables:              18

Total constraints:              27
Nonlinear constraints:          0

Total nonzeros:                174
Nonlinear nonzeros:            0

Variable      Value      Reduced Cost
Y1            1.000000    -14.000000
Y2            1.000000    -30.000000
Y3            1.000000    -11.000000
Y4            1.000000    -11.000000
Y5            1.000000    -15.000000
Y6            1.000000    -20.000000
Y7            0.000000    -38.000000
Y8            0.000000    -26.000000
Y9            1.000000    -29.000000
Y10           0.000000    -32.000000
Y11           0.000000    -20.000000
Y12           0.000000    -34.000000
Y13           0.000000    -194.000000
Y14           0.000000    -37.000000
Y15           0.000000    -36.000000
Y16           0.000000    -39.000000
Y17           0.000000    -64.000000
Y18           0.000000    -68.000000
E             0.3342391    0.000000
V             0.4486957    0.000000
G             0.1000000E-01    0.000000
NU            0.1000000E-01    0.000000
L             0.1000000E-01    0.000000
NE            0.1870652    0.000000

```

Figure 8: results to the optimization

5.2: Evaluating the Survey Data

A 21-question survey was conducted with a sampling size of seventeen high school students. The responses and their scores were derived from research and the personal experiences of the researchers. The type of questions used were Likert scale questions, independent and dependent multiple-choice questions, and a free response question. Each question will be assigned a score based on the question's answers as well as their type.

The importance of the question scores was to derive a quantitative score from each question and insert it in the column of customer importance in the HoQ in figure 13. This score would effectively translate the qualitative data of the surveys into numerical value used in the HoQ.

5.2.1: The Likert Scale Questions

The first type of questions in the survey were Likert scale questions. The survey had seven in total. The Likert scale questions were the simplest to put into the HoQ because the list of responses was always the same. They were always: strongly agree, agree, neutral, disagree, or strongly disagree. This means that the scores remained consistent. The scores associated with each response are shown in figure 9 below:

Strongly agree	2
Agree	1
Neutral	0
Disagree	-1
Strongly Disagree	-2

Figure 9: Scoring system for a Likert scale question

The first Likert scale question was: “*I will use what I learned in class in the last 3 months:*”. This question asked for a student's voice on the Value-added Learning metric of the six factors. The questions and responses are given below:

I will use what I learned in class in the last 3 months:
17 responses

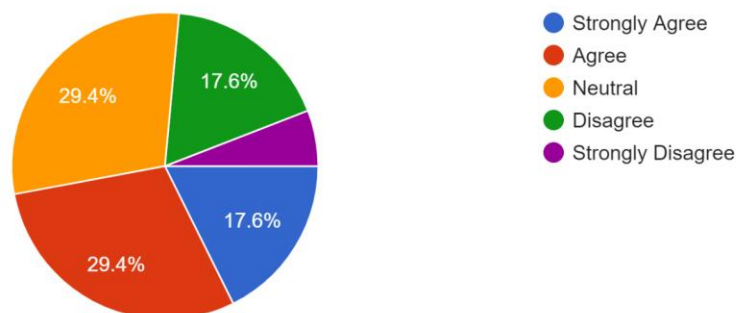


Figure 10: Responses to Likert Q1

Most of the students surveyed either agreed or were neutral (both at 29.4%). The score for all of the Likert scale questions were generated by multiplying the percentages found in the survey by the corresponding choice score. Then, these scores were added together to form the final question score. For example, the strongly agree percentage from the chart above was .176, and the choice score for strongly agree was 2. The products of these two variables were: 0.352, but this is not the final question score. This same process must be done for the other responses

and all the other responses must be totaled. The total score for this question was 0.352. This total score would then be sorted into which customer requirement the question satisfied.

Each score could go into multiple categories. In this case the question score: 0.352 was added to the course rigor, teacher competency, career planning services, and current employment categories. This is because of how the question was constructed. The wording combined with the literature review proved these sections to be the most impacted by the responses.

The second Likert question was “I am confident about the future”, listed in figure 11 below. The total question score was 0.882, and was placed in the career planning services, current employment, and teacher competence categories of the house of quality.

I am confident about the future:

17 responses

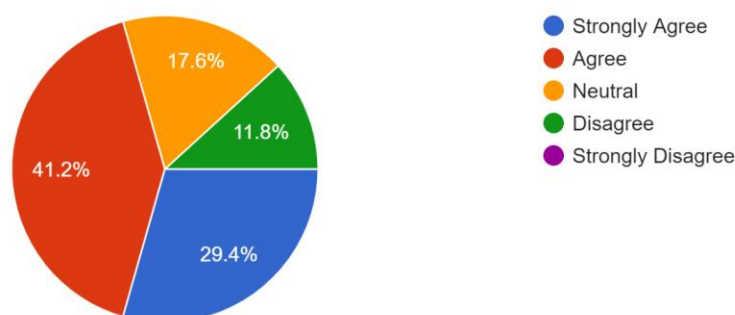


Figure 11: Responses to Likert Q2

The third Likert question asks students if their classes helped them determine the career path they wanted to pursue shown in figure 12 below.

My classes helped me determine what career path I would like to pursue?

17 responses

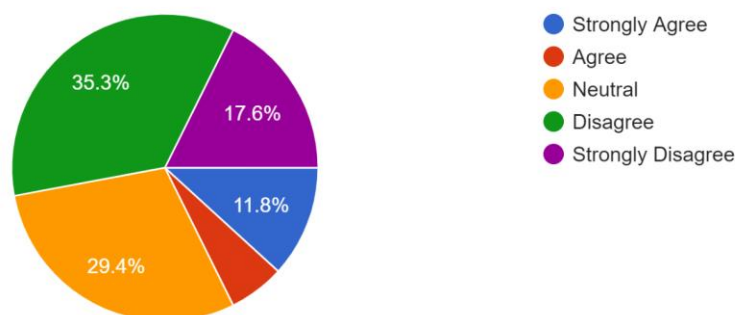


Figure 12: Responses to Likert Q3

The question measures the value-added learning factor, and the total question score was - 0.41. The score was placed in the career planning services, teacher competence, and course rigor categories in the HoQ. The question was mainly about career planning since it asked students if their courses helped them select a career. This also ties into course rigor because if a course that ties into a career is too difficult, the student may choose not to pursue that career. Then, last but not least, competent teachers help students choose courses to take, and this leads to helping students select a career.

The fourth Likert question asked students if their school reveals any opportunities after high school in figure 13, shown below.

My school reveals opportunities that I have after my high school career.

17 responses

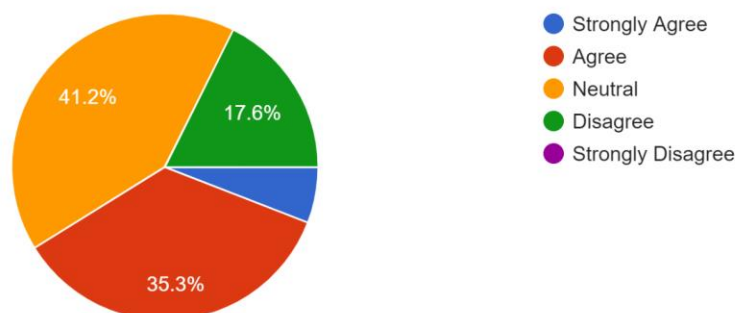


Figure 13: Responses to Likert Q4

This question measured the network-ability, and engagement factors. The total score for this question was 0.295 and was placed under extracurricular activities, career planning, and teacher competence.

My teachers ask their students to participate in class

17 responses

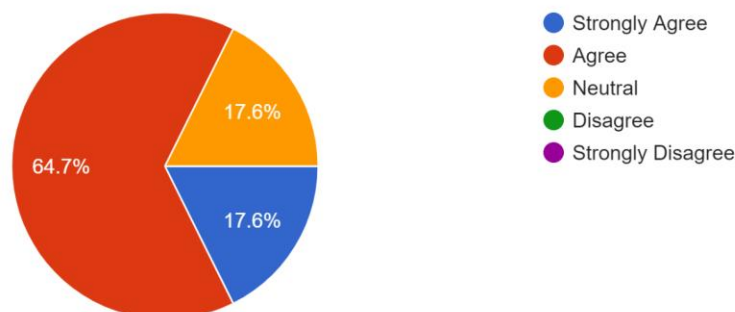


Figure 14: Responses to Likert Q5

The fifth Likert question in figure 14 above asks if the teacher asks students to participate in class. This question measures the engagement factor because teachers that ask students to participate in their classes will increase student engagement. The total score for this question was 0.999 and was placed under teacher competency, course rigor, and course options. This is because if students have a good teacher that engages them, then they may be willing to put up with a rigorous course and choose a certain course.

Figure 15 asks students if they can still make a living without school. The question mostly measured value-added learning by asking students if they needed their school. Surprisingly, 52.9% agree with this statement, while only 17.6% disagree. The total score for this question was 0.705.

Without my classes/School I can still make a living:

17 responses

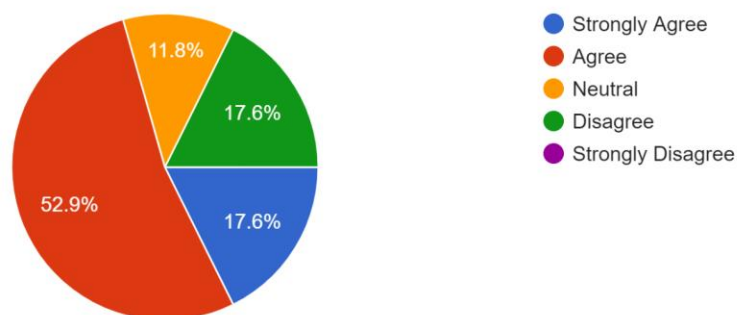


Figure 15: Response to Likert Q5

This score was then placed under career planning, current employment, and parental involvement sections of the house of quality.

Group work is necessary for success:

17 responses

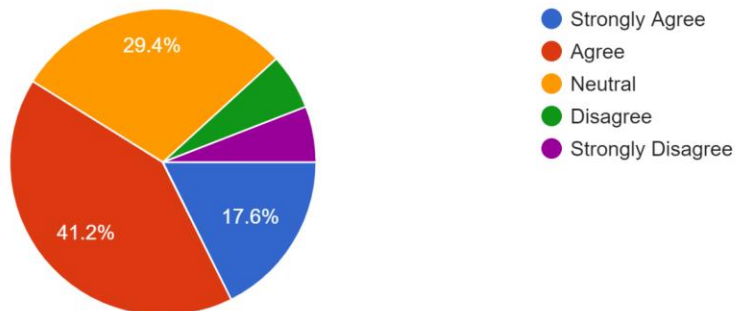


Figure 16: Responses to Likert Q7

In figure 16 above most students agree that group work is necessary for success at 41.2%. The total score from this question was 0.41 and was placed in extracurricular activities, career planning, current employment, course rigor, and teacher competence in the house of quality.

5.2.2: Multiple Choice Questions

The second style of question was the multiple-choice questions. The survey had a total of thirteen multiple choice questions. It proved to be tricky in producing a question score from these questions because unlike the Likert scale questions, these questions did not always have the same number of answers, and the answers could be different from one another. In order to accurately score these questions, the researchers used the knowledge gained from the literature reviews, and the category of responses themselves to score them. Each multiple-choice question had either an Independent or dependent response.

5.2.2.1: Type 1 Multiple Choice Scoring: Independent Responses

Independent multiple point responses were constructed for questions whose answers were independent of one another. This means unlike Likert [or dependent in the next section], the scores for all the questions are 1 multiplied by the percentage the responses took. This is to give each response a value to incorporate into the house of quality. There are 2 exceptions that will be explored further down.

One of the multiple-choice questions that was scored was: “I Learn Best when?” This multiple-choice question is classified as an independent response because each response gets a score, and it does not depend on another question. Here are the responses below in figure 17:

I learn best when:
17 responses

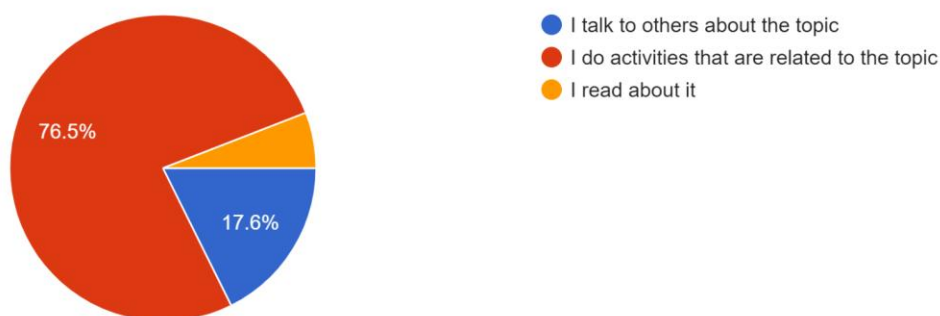


Figure 17: Independent Response Q1

Most student’s response to this question was that they learn best when they perform activities related to the topic of their learning (76.5%) In order to apply the scale, the percentages, in this case .765 (76.5%) was multiplied by 1. Then this .765 was sent to a customer requirement, in this case teacher competency, and course options section. While, the response “I read about it”, was sent to another customer requirement: course rigor. And finally, the activities response score was sent to course rigor and extracurricular activities.

The second question asked was: “which subject has the least impact on your day to day”. This question measured the Value-added learning factor. The scores were placed next to the teacher competence, and current employment sections in the house of quality. The results are shown in figure 18 below.

Which Core subject has the least impact on your day to day?

17 responses

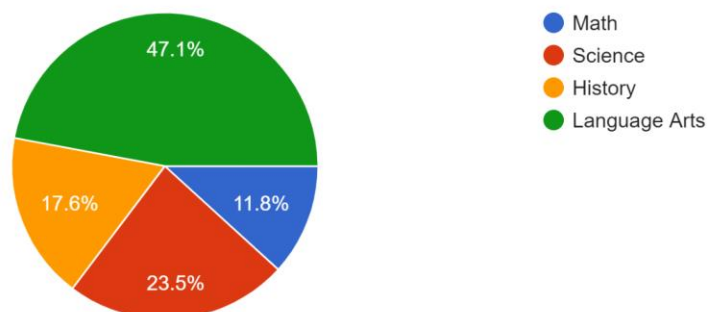


Figure 18: Independent Response Q2

The scores for this question were ranked by which subject had the least impact on a student’s life. The results of the responses were converted to negative to show a reduction of importance.

The third question asked: “Which core subject has the most impact on your day to day?”, shown below in figure 19. This question was the inverse of the previous question. The responses become positive while the house of quality sections the scores were placed in did not change.

Which Core subject has the most impact on your day to day?

17 responses

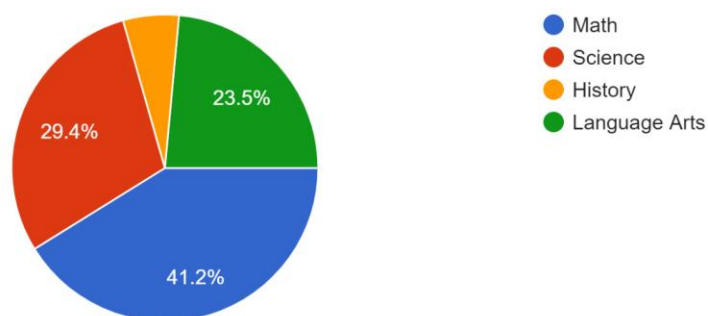


Figure 19: Independent Response Q3

The fourth question asked students what they planned to do after school, and the results are shown in figure 20. This question was related to the engagement factor because students who are engaged in their studies are able to figure out what they want to do with their lives versus unengaged students.

The scores for this question were placed in the career planning services, parental involvement, and diploma categories of the house of quality.

I plan to ___ after school:

17 responses

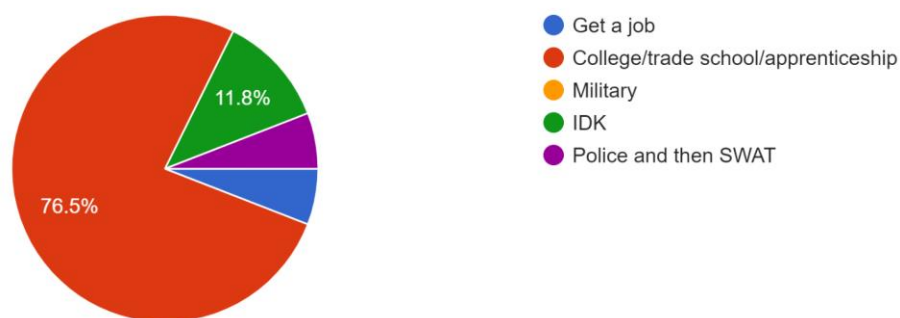


Figure 20: Independent Response Q4

The fifth question asks students: “which course they are the most proficient at” (figure 21). This question measures literacy, and numeracy since these two skills apply to the courses listed below. The questions were placed in the sections with high numeracy and literacy measures: course options, and teacher competence.

Which Core subject are you most proficient at?

17 responses

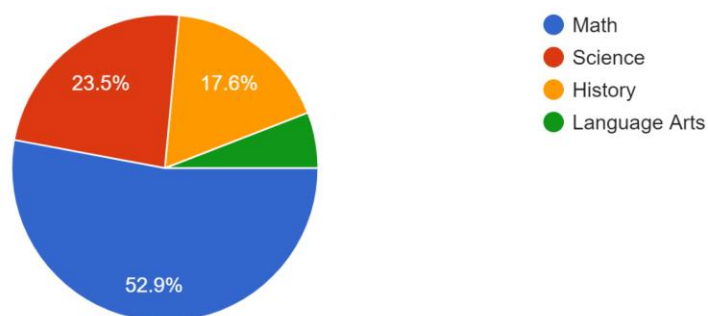


Figure 21: Independent Response Q5

Of all the type 1 multiple choice questions this 1 is one of the two exceptions. The scores for the answers were derived mainly by how many students selected that choice. Math was

scored a 2 because it had the highest number of responses. Then science was scored a 1, history a 0, and language arts a -1. When the percentages were multiplied by their corresponding score, and then totaled, the score was 1.234.

The reason for this exception is the researchers wanted to know what core subject students were most proficient at, but did not view any subject more important than the other. Most students were the most proficient at math at 52.9%. This makes sense considering most students felt math was the most important core subject. The classification comes from the answer's utility being 0.

The sixth independent question asked students why they take certain electives. The responses are in figure 22. Skills were ranked zero because none of the students surveyed chose that answer. The score for the response "fun" was .471, and was placed in the course options, and extracurricular activities categories. The score for career was .176, and was placed under career planning services, while the score for credit was placed under the diploma category.

I take electives mostly for:

17 responses

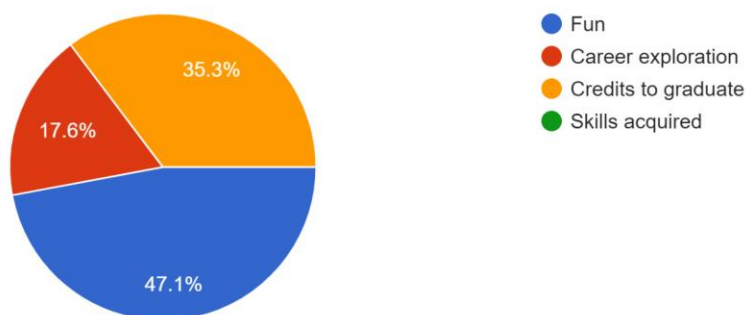


Figure 22: Independent Response Q6

The seventh question wanted to know why students took AP, or IB classes. The question measured value added learning since many of the response options were primarily about the student seeing value in the classes. The scores assigned to the options were 1 for college credit, 1 for knowledge's sake, 1 for bragging rights, and 0 for I didn't. College credit and knowledge's sake were ranked the highest. "I didn't" was ranked 0 because it meant the student did not take an AP course at all, and that does not aid the researchers. The responses were placed in course options, course rigor, diploma, and career planning categories, respectively. The results were shown in figure 23 below.

I took higher level (ap,ib) core classes primarily to / for:

17 responses

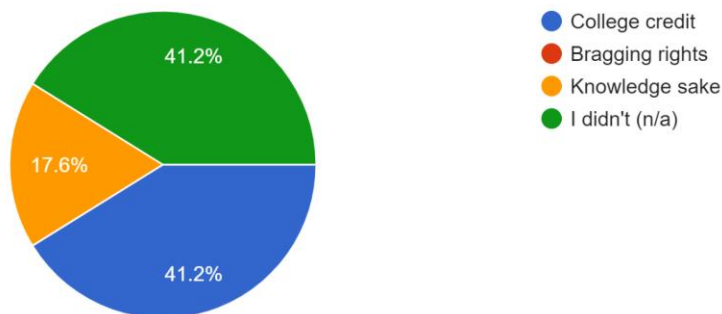


Figure 23: Independent Response Q7

The eighth question cross-examined students' engagement factor by asking what they enjoyed the most about their classes. The responses and results are shown in figure 24 below.

What I enjoy about my classes are:

17 responses

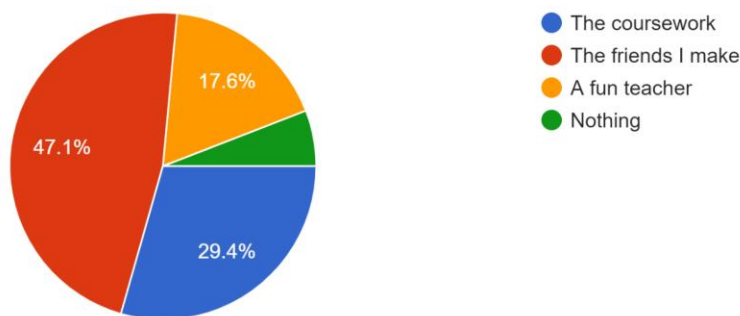


Figure 24: Independent Response Q8

The scores for the responses are as follows: 3 for “coursework”, 2 for “a fun teacher”, 1 for “the friends I make”, and 0 for “nothing”. The option “nothing” was ranked 0 because it means that that student enjoys nothing about his/her courses, and it does not help the researchers discover what makes a particular course enjoyable. The total score was 1.705, and was placed under course options, teacher competency, good security, diploma, and course rigor categories in the house of quality. The exception is made here for the same reason as the fifth example (figure 21).

5.2.2.2: Type 2 Multiple Choice Scoring: Dependent Responses

The second multiple question type is the dependent multiple-choice question. Responses in this category were deemed to have different levels of utility. This means that although the total response scores will go to the same customer requirement section(s); the individual responses will not be separated. This is similar to Likert scale when reporting in the HoQ.

The first question used is “How active are your parents in your school life?” The responses are shown below in figure 25.

How active are your parents in your school life?
17 responses

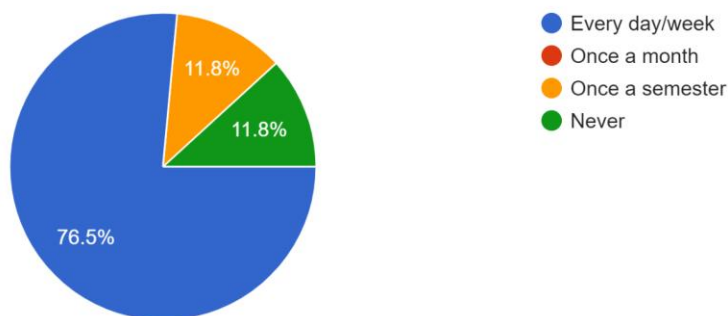


Figure 25: Example of dependent response question

The scoring system for this question was based mostly on literature review that states that the more parents are involved the more students succeed. The response “once a month” was scored zero due to no responses, and “never” was scored a -1. The scores for “every day/ week” was 2, while the score for once a semester was 1. Then, just like the Likert scale, the percentages are multiplied by the scores. This resulted in a score of .766. Then, these products are summed and placed into a customer requirement category. In this question’s case, it was parental involvement, extracurricular activities, good security, clean facilities, current employment, career planning services, and course options.

This question also has a follow up question asking how many times the school contacts a student’s family. The responses are shown in figure 26 below:

How often does the school contact your family?

17 responses

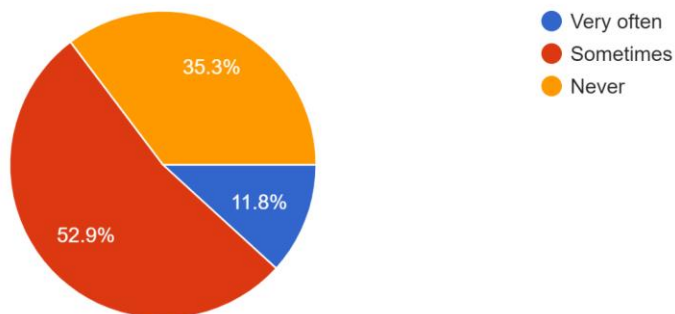


Figure 26: Dependent Response Q2

The reason the researchers included this follow up question was because it was proven that the more a school contacts a parent over poor behavior, the more negative the impact was on the child. This question also helps measure an aspect of student engagement. The school would contact a student's parent sometimes at 52.9%, while 35.3% of students found that the school never contacted their parent, and 11.8% for very often. The question was then scored: very often: -1, sometimes:0, and never:1. The total score was 0.235 and was placed in the same categories as the previous question.

The third question in this category was "Do you have a job", and is inquiring if students are currently employed. This question measures the network-ability factor. The total score for this question was 1.766, and was placed in current employment and the extracurricular activities categories in the house of quality. The results are shown in figure 27 below:

Do you have a job?

17 responses

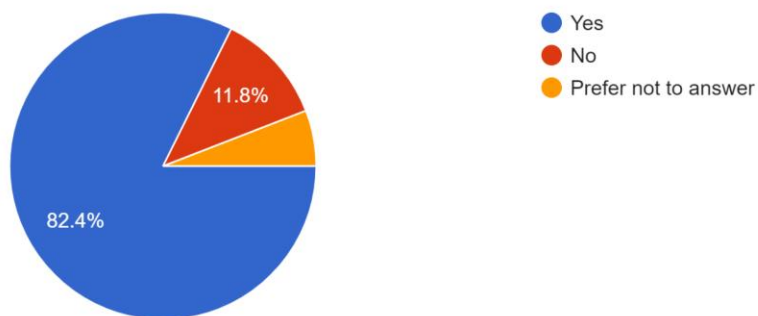


Figure 27: Dependent Response Q3

The scores from this question were ranked by the number of responses, and importance to the project. The answer yes was ranked a 2 because it had the most responses, while no was ranked 1 for having the second the greatest number of responses. The option to not answer was given a 0 because it adds no value to the project, since we wanted to know if a student has a job or not.

The final dependent question asks students if they participate in extracurricular activities in figure 28 shown below. This question measures engagement, for extracurricular activities have a strong impact on engagement. The total score for this question was 1.529 and was placed in the extracurricular activities, parental involvement, and the diploma categories.

Do you participate in extracurricular activities?

17 responses

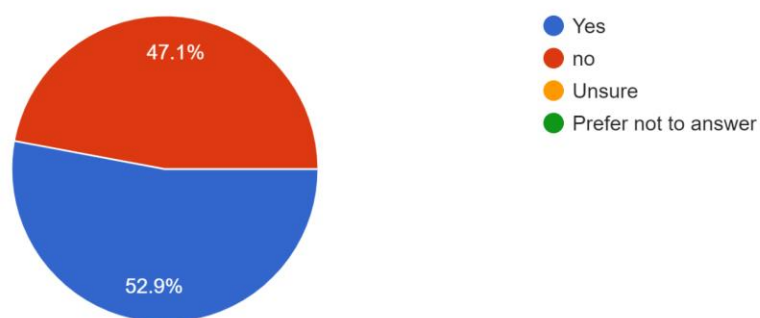


Figure 28: Dependent Response Q4

The question was scored by ranking the “yes” answer as a 2 because it got the most responses and was linked to student success in the literary review. The response “no” was given a 1, and the responses “unsure” and “prefer not to answer” were given a 0 because there wasn’t a student that selected that response. The percentages were then multiplied by their given score, and then were totaled to give the final score of 1.529.

5.2.3: Free Response Question

The last type of question in the survey was the free response question. There was only one free response question on the survey, and it provided the voice of the student unconstrained by any answer choices provided by the researchers. The question in the survey said “How would you improve the school experience?” One student responded “by not being in school”, and this response was omitted because this response does not help us with our project in any way. Despite some bad answers, most of the responses can be grouped into four main customer

requirements: teacher competency, course options, and good security. The answers with the most impact was teacher competency since it had the most responses. The score given to teacher competency was 3, and the score went to the teacher competency category on the house of quality. Course options were given a two, and good security was given a one. This was due to the unconstrained nature of the question. The free responses are shown in figure 29 below:

How would you improve the school experience?

By studying more

Better teachers and courses

Teachers being more involved.

i wouldn't change anything a good environment

By giving teens the option to take class that help determine a career path.

by not being in school

Actually, having teachers who know how to communicate what their teaching to the students not just teachers who know how to right down some notes.

Not having to worry about getting taken out of class and disrupting my learning due to my clothes

Better between students and teachers

More mental health options

Make Literature an elective

Add a class that teaches you how to do bills and taxes

Not sure

Interactive learning

Creative learning experiences that allow teachers to interact with students.

Nah it'll suck regardless

Figure 29: Free Responses

5.3: The House of Quality

The HoQ (figure 30) was used to measure the strength of the customer requirements in relation to the six decision variables.

Relative Weight	Customer Importance	Customer Requirements	Functional Requirements					
			Engagement	Value added Learning	Network-ability	Numeracy	Literacy	Graduation rate
11%	7.255	Parent involvement	●	●	▽	▽	▽	○
11%	7.254	Extracurricular activities	○	▽	●	▽	▽	▽
14%	9.57	Course options	●	●	▽	▽	▽	▽
10%	6.696	Course Rigor	○	●	▽	●	●	○
12%	8.011	Diploma/GED/ Certificate	○	○	○	○	○	●
11%	7.441	Teacher Competence	●	▽	○	●	●	○
6%	4.128	Good Security	▽	○	○	▽	▽	○
4%	2.375	Clean Facility	▽	▽	▽	▽	▽	○
14%	9.446	Career planning services	●	●	●	▽	○	●
8%	5.628	Current employment	○	●	●	●	●	▽
Importance Rating Sum (Impor			579.14	591.18	421.2	356.83	384.69	388.25
Relative Weight			21%	22%	15%	13%	14%	14%

Correlations	
Positive	+
Negative	-
No Correlation	
Relationships	
Strong	●
Medium	○
Weak	▽
Direction of Improvement	
Maximize	▲
Target	□
Minimize	▼

Figure 30: Filled in House of quality

The question scores derived from the survey are under customer importance (i.e., what the schools offer to help students succeed). The ranking of importance of the six factors to the

customer requirements is at the heart of the house of quality. The dark dots represent a strong correlation between the requirement and a factor, while the light dot represents a medium correlation. The triangle represents a weak correlation.

Once the scores were entered, the Blue Barred only had to select the strength of the relationship between customer requirement and the decision variable. For example, the researcher deduced that parental involvement had a strong impact on engagement. After the researchers filled in the heart of the HoQ, the template determined the relative weights. These are the percentages below the heart of the HoQ. Larger percentage values correspond to higher values of a specific metric.

As stated earlier, this model was used to determine which factor had the largest impact on student success. The relative weight percentages from the HoQ were used to build a Pareto chart. This chart graphically demonstrates which factor is lacking and causing the most student failure.

5.4: The Pareto Chart

The pareto chart below demonstrates which factor is lacking and causing the most issues. In this case it is value added learning. Both the Pareto chart and the optimization model agree that value added learning has the biggest impact on student success.

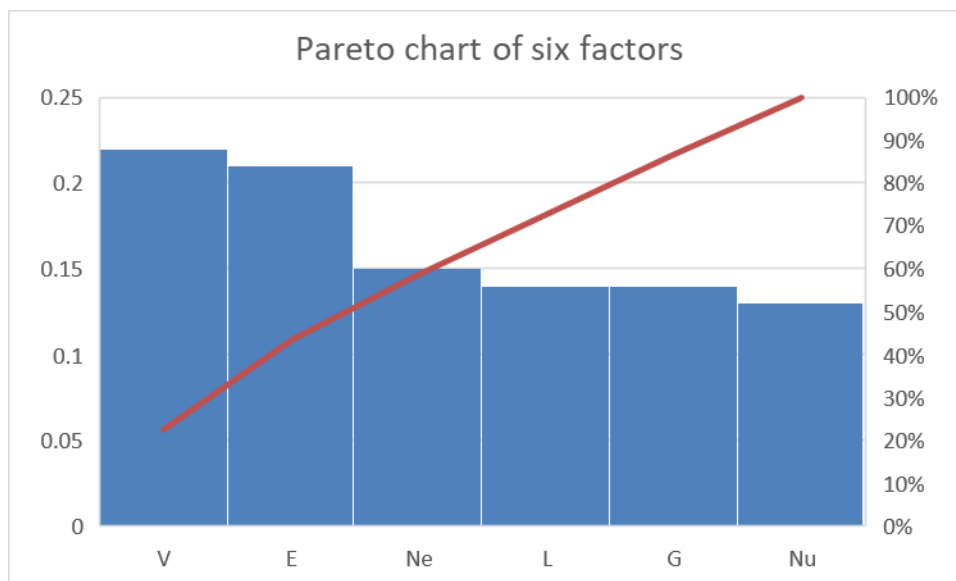


Figure 31: Pareto Chart

Chapter 6: Discussion

The Blue Barred determined that Value added Learning (**VaL**) had the biggest impact on student success based on the results of the optimization model and the confirmation that was derived from the HoQ and Pareto chart. From early on in the literature review, VaL and engagement seemed to have the strongest impact on student success. The surveys also confirmed that VaL had a strong impact on student success because when asked, the majority of students claimed that they did not see the benefit of what they learned from class. The Blue Barred also believes that for the question that asks students which core course has the most impact on their life, VaL could explain why some of the responses were the way they were. One theory is students cannot enjoy or apply what they learned in these classes if the perception of course concepts are low.

The value aspect tied more into the career aspirations of students as determined by the House of quality. The customer requirements, career planning services, and current employment is where students were able to see the utility of what they learned. In the survey, students stated they were the most proficient at math, and math had the most efficacy in their lives. From the literature review, it was found that most employers value literacy, numeracy, and punctuality from their workers. This information confirms why VaL may be the most important factor.

Most students work, and at most workplaces, basic or complex math is used to solve problems. This may point to why students felt that math had the biggest impact on their life. This necessity may be why they were the most proficient at it.

Although value added learning had the largest impact, it does not mean that the other factors had no impact. Engagement was the second highest decision variable that contributed to maximizing the number of job opportunities that are open to a student. As stated earlier from the literature review, the two sub-factors that impacted engagement were parental involvement and motivation.

The Blue Barred recommends that GCPS schools focus on ensuring that students see the value in what they learn, so in this way, every student has the opportunity to maximize his or her chances at finding a career in which they are proficient as well as a career that brings them enjoyment. The main way this can be accomplished can be through teacher student relations. To achieve this, teachers and the school board can adjust how courses are taught. Many studies found that students learn more through hands-on work, and the majority of students surveyed agreed that teachers should use different learning methods. This does not mean neglect the other methods of teaching

Chapter 7: Conclusions

7.1 Limitations

Despite the success of the optimization model and its confirmation by the HoQ, the project still has its limitations. The major issue was the sampling size. The number of students surveyed was seventeen which is far below the bare minimum needing to be surveyed. One of the main barriers to collecting the required student data was IRB restrictions. The researchers needed to pass through the IRB in order to meet with and collect data from students. Since the researchers missed the important date from the IRB, the blue barred decided to outsource the survey to other parties. However, this produced suboptimal results.

The other issue was the question scoring of the industries. The scores were based on industry data that may be outdated. This can be resolved by updating the model with new information and updating the scoring section of the model.

7.2 Recommendation

It is important for GCPS to focus on improving value-added learning followed by engagement and network-ability in order to improve the number of successful students produced. The optimization model, and the HoQ both confirmed this factor to be the most important factor to student success.

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Appendices

Appendix 1: Acknowledgements

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Appendix 3: Reflections

Ricky:

I learned a ton in this course about teamwork, technical skills required, and how systems work. Not everyone has all the skills. The major value of a team is we can achieve the same goal while specializing in our particular position. For the future, I plan to use the knowledge I gained to promote healthy practices in a business. This requires me to know how to do this. I plan to learn more skills as well as understand things I don't know.

The setbacks made in this project were a good lesson in bureaucracy, modern safety, and societal standards. The systems were put in place to help us. They also cause some problems that make it hard for people to do things in a "proper" way. The major advantage I saw from the setbacks was it forced me to think creatively.

Elena:

This project made me brush up on every course and tool throughout my time in college. The project gave me application of tools like product mix models, pareto charts, and house of quality. Applying the following tools helped me understand how to use them, and when to use them. The project also gave me a taste of what a project in the workforce could look like, and what the expectations might be.

The major lesson I learned during this project was the value of planning ahead. We did not plan the project well, so this led to procrastination. The consequences of this were late nights, and increased stress. So, a personal lesson I learned from this project that I will apply to my professional life is to plan ahead, whether this be other projects, or just planning a month out.

Despite the lack of planning, me and my group still managed to succeed. Towards the end of the semester, we came together using our creativity and perseverance to finish this project. When we improved ourselves we all began to see the value in our project, and we began to see success with our project.

Andrew:

If there was ever a course that pushed me to my limits the most, Senior Project Design would be that course. Honestly, it really isn't about getting the best grade or winning a money prize at the end of the semester. I believe a more accurate depiction of success in this course can be seen in the Blue Barred. We demonstrated a true sense of grit and determination in getting this project complete.

One primary setback that I noticed is that we did not stay on top of this project at the beginning of the semester, so as the semester came to a close, it did become very stressful at certain times. However, in these moments of feeling supremely overwhelmed, we stayed true to

our project, and we persevered. In retrospect, I would say that we should have chosen a topic that is not as difficult to explain in 10- minute presentations throughout the semester. Our topic is really interesting, but it is not always the easiest task to explain an optimization model or how we came up with the mathematical formula for the sector score in such short durations of time.

I don't regret going through the fire for this project, and I'm grateful to have worked alongside great classmates. We didn't always agree on everything or how we should approach something; however, we did agree on one thing and that was performing the absolute best we could on this project. Like a lot of difficult tasks, this project essentially just made the earning of my Industrial Engineering degree that much more worthwhile, and this truly will not be an experience that is forgotten.

Table 3

Left scored Table									
Industry name	Eng score	Val score	Grad score	Num score	Lit score	Net score	Total jobs		
Educational services	0.15	0.31	0.34	0.04	0.08	0.09	14	1.00	0.0195
Agriculture, Forestry...	0.26	0.30	0.08	0.14	0.09	0.14	30	1.00	0.0418
Utilities	0.20	0.11	0.29	0.25	0.04	0.10	11	1.00	0.0153
Mining	0.26	0.25	0.08	0.09	0.14	0.18	11	1.00	0.0153
Accommodations/ food..	0.14	0.13	0.08	0.24	0.19	0.22	15	1.00	0.0209
Art, Edu, & recreation	0.26	0.18	0.16	0.05	0.18	0.18	20	1.00	0.0279
Transportation	0.23	0.13	0.08	0.19	0.14	0.22	38	1.00	0.0529
Admin, bus, and waste	0.09	0.06	0.24	0.18	0.22	0.21	26	1.00	0.0362
Other (except public admin)	0.17	0.31	0.08	0.09	0.13	0.21	29	1.00	0.0404
Finance/insurance	0.08	0.06	0.30	0.26	0.21	0.10	32	1.00	0.0446
Real estate/ rental/ leasing	0.13	0.06	0.16	0.19	0.23	0.22	20	1.00	0.0279
Healthcare, social assistance	0.12	0.32	0.28	0.04	0.08	0.16	34	1.00	0.0474
Manufacturing	0.26	0.06	0.16	0.23	0.18	0.11	194	1.00	0.2702
Construction	0.27	0.13	0.08	0.14	0.19	0.18	37	1.00	0.0515
Professionalism science, tech	0.13	0.12	0.08	0.28	0.23	0.15	36	1.00	0.0501
Information	0.04	0.12	0.23	0.22	0.26	0.14	39	1.00	0.0543
Retail trade	0.14	0.13	0.08	0.19	0.23	0.22	64	1.00	0.0891
Wholesale trade	0.09	0.19	0.08	0.19	0.23	0.22	68	1.00	0.0947

Table 4

Right Scores table									
Industry name	Eng score	Val score	Grad score	Num score	Lit score	Net score	Total jobs	% of total jobs	Total Score (\$)
Educational services	0.0201	0.0421	0.0462	0.0053	0.0103	0.0122	14	0.0195	0.1362
Agriculture, Forestry...	0.0645	0.0752	0.0198	0.0342	0.0221	0.0350	30	0.0418	0.2508
Utilities	0.0197	0.0110	0.0290	0.0251	0.0041	0.0096	11	0.0153	0.0985
Mining	0.0236	0.0221	0.0073	0.0084	0.0122	0.0160	11	0.0153	0.0895
Accommodations/ food..	0.0161	0.0150	0.0099	0.0285	0.0221	0.0262	15	0.0209	0.1179
Art, Edu, & recreation	0.0430	0.0301	0.0264	0.0076	0.0295	0.0292	20	0.0279	0.1657
Transportation	0.0680	0.0381	0.0251	0.0577	0.0420	0.0665	38	0.0529	0.2974
Admin, bus, and waste	0.0186	0.0130	0.0515	0.0395	0.0479	0.0455	26	0.0362	0.2160
Other (except public admin)	0.0415	0.0727	0.0191	0.0220	0.0321	0.0507	29	0.0404	0.2382
Finance/insurance	0.0229	0.0160	0.0844	0.0729	0.0590	0.0280	32	0.0446	0.2833
Real estate/ rental/ leasing	0.0215	0.0100	0.0264	0.0304	0.0369	0.0350	20	0.0279	0.1601
Healthcare, social assistance	0.0365	0.1023	0.0897	0.0129	0.0251	0.0496	34	0.0474	0.3161
Manufacturing	0.4169	0.0973	0.2560	0.3684	0.2861	0.1697	194	0.2702	1.5943
Construction	0.0795	0.0371	0.0244	0.0422	0.0546	0.0539	37	0.0515	0.2917
Professionalism science, tech	0.0387	0.0361	0.0238	0.0820	0.0664	0.0420	36	0.0501	0.2889
Information	0.0140	0.0391	0.0772	0.0741	0.0863	0.0455	39	0.0543	0.3361
Retail trade	0.0688	0.0642	0.0422	0.0972	0.1180	0.1119	64	0.0891	0.5023
Wholesale trade	0.0487	0.1023	0.0449	0.1033	0.1253	0.1189	68	0.0947	0.5435
							718	1.00	

Survey 1

S2S student survey

- 1) What grade are you in?
 - a) 9th
 - b) 10th
 - c) 11th
 - d) 12th
 - 2) I will use what I learned in class in the last 3 months:
Strongly Agree; Agree; neutral; Disagree ;Strongly Disagree
 - 3) Which Core subject has the least impact on your day to day?
 - a) Math
 - b) Sciences
 - c) History
 - d) Language arts
 - 4) Which Core subject has the most impact on your day to day?
 - a) Math
 - b) Sciences
 - c) History
 - d) Language arts
 - 5) I plan to ___ after school:
 - a) Get a job
 - b) College/trade school/apprenticeship
 - c) Military
 - d) IDK
 - e) Other (Please fill in) _____
 - 6) Do you have a job?
 - a) Yes
 - b) No
 - c) Prefer not to answer
 - 7) I am confident about the future:
Strongly Agree; Agree; neutral; Disagree ;Strongly Disagree
 - 8) My classes helped me determine what career path I would like to pursue?
Strongly Agree; Agree; neutral; Disagree ;Strongly Disagree
 - 9) Do you participate in extracurricular activities?
 - a) Yes
 - b) No
 - c) Unsure
 - d) Prefer not to answer
 - 10) Which Core subject are you most proficient at?
 - a) Math
 - b) Sciences
 - c) History
 - d) Language arts
 - 11) My school reveals opportunities that I have after my high school career.
Strongly Agree; Agree; neutral; Disagree; Strongly Disagree
-

S2S student survey

12) How active are your parents in your school life?

- a) Every day/week
- b) Once a month
- c) Once a semester
- d) Never

13) How often does the school contact your family?

- a) Very often
- b) Sometimes
- c) Never

14) How would you improve the school experience?

15) I take electives mostly for:

- a) Fun
- b) Career exploration
- c) Credits to graduate
- d) Skills acquired

16) I took higher level (ap,ib) core classes primarily to / for:

- a) College credit
- b) Bragging rights
- c) Knowledge sake
- d) I didn't (n/a)
- e) Other (please fill) _____

17) What I enjoy about my classes are:

- a) The coursework
- b) The friends I make
- c) A fun teacher
- d) Other (please fill) _____

18) My teachers ask their students to participate in class

Strongly Agree; Agree; neutral; Disagree ;Strongly Disagree

19) Without my classes/School I can still make a living:

Strongly Agree; Agree; neutral; Disagree ;Strongly Disagree

20) I learn best when:

- a) I talk to others about the topic
- b) I do activities that are related to the topic
- c) I read about it
- d) Other (please fill in) _____

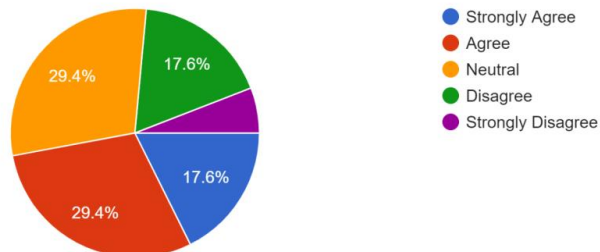
21) Group work is necessary for success:

Strongly Agree; Agree; neutral; Disagree ;Strongly Disagree

Survey Results Question 1

I will use what I learned in class in the last 3 months:

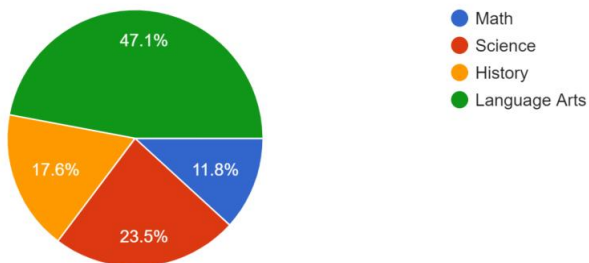
17 responses



Survey Results Question 2

Which Core subject has the least impact on your day to day?

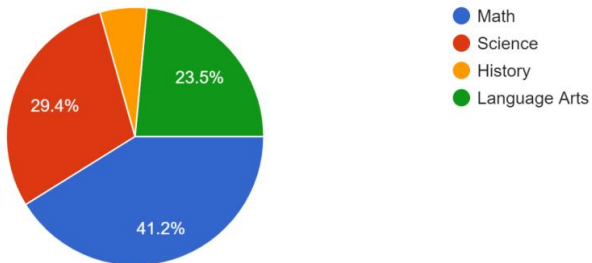
17 responses



Survey Results Question 3

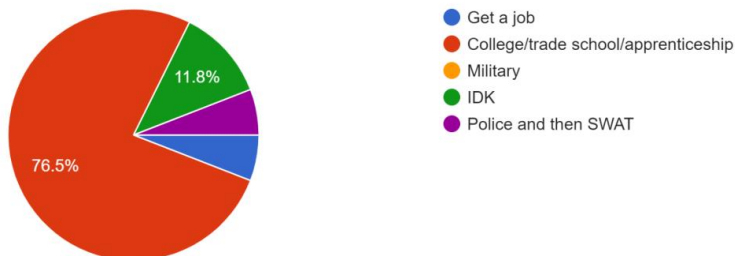
Which Core subject has the most impact on your day to day?

17 responses



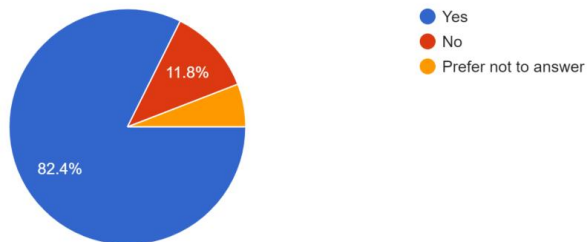
Survey Results Question 4

I plan to ___ after school:
17 responses



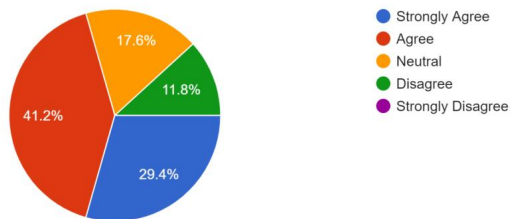
Survey Results question 5

Do you have a job?
17 responses



Survey Results Question 6

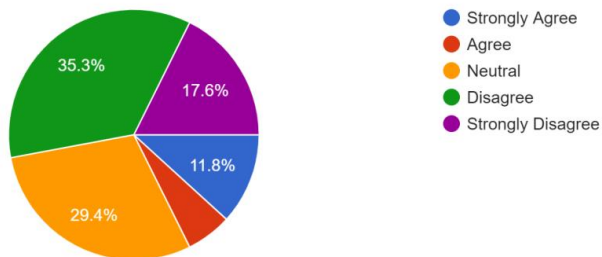
I am confident about the future:
17 responses



Survey Results Question 7

My classes helped me determine what career path I would like to pursue?

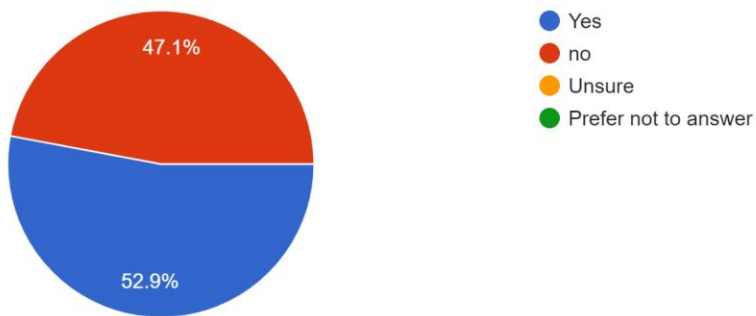
17 responses



Survey Results Question 8

Do you participate in extracurricular activities?

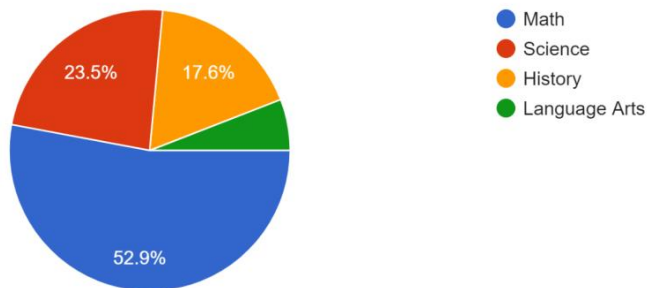
17 responses



Survey Results Question 9

Which Core subject are you most proficient at?

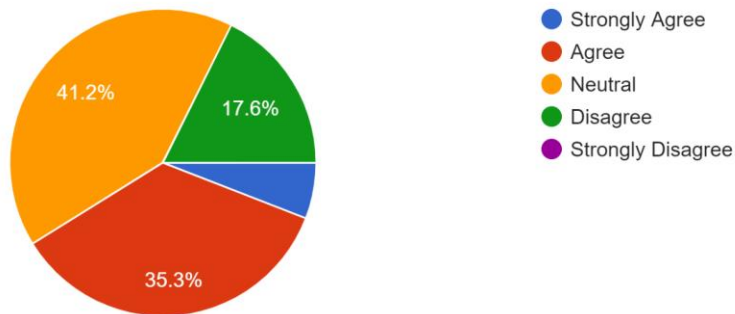
17 responses



Survey Results Question 10

My school reveals opportunities that I have after my high school career.

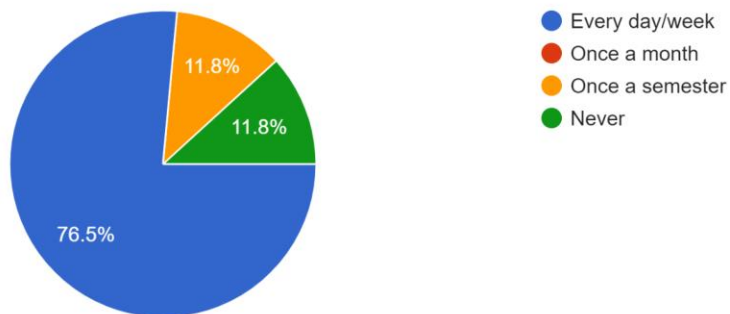
17 responses



Survey Results Question 11

How active are your parents in your school life?

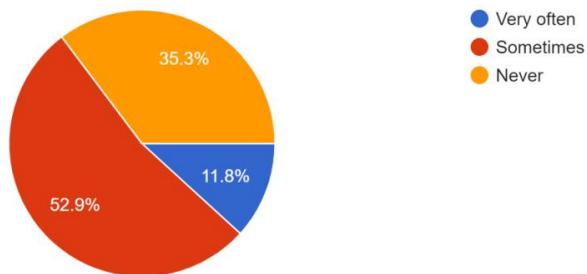
17 responses



Survey Results Question 12

How often does the school contact your family?

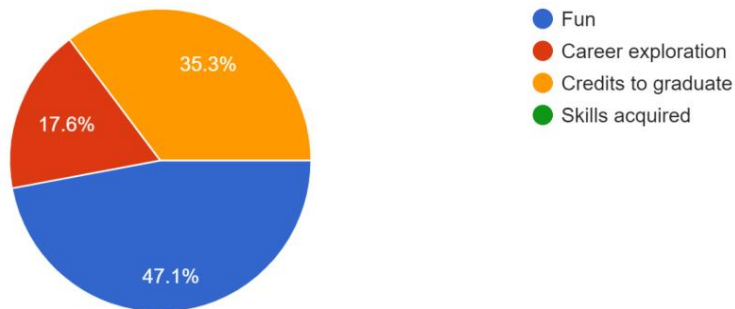
17 responses



Survey Results Question 13

I take electives mostly for:

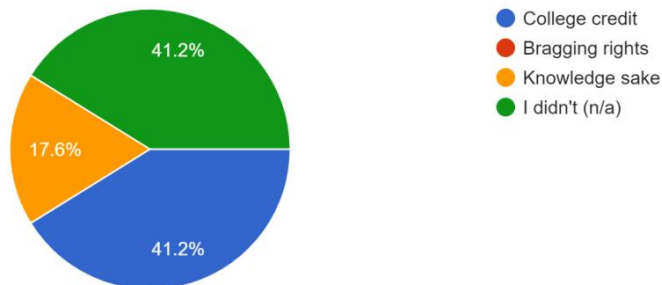
17 responses



Survey Results Question 14

I took higher level (ap,ib) core classes primarily to / for:

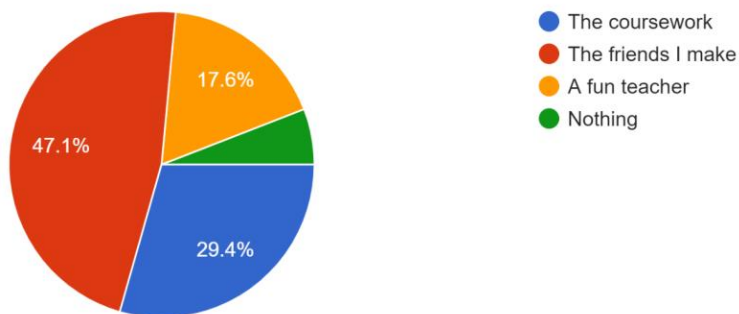
17 responses



Survey Results Question 15

What I enjoy about my classes are:

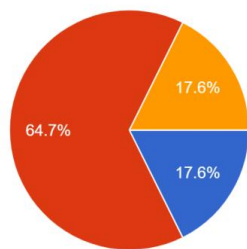
17 responses



Survey Results Question 16

My teachers ask their students to participate in class

17 responses

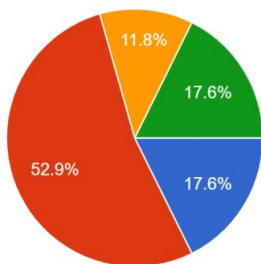


- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

Survey Results Question 17

Without my classes/School I can still make a living:

17 responses

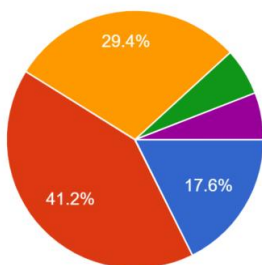


- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

Survey Results Question 18

Group work is necessary for success:

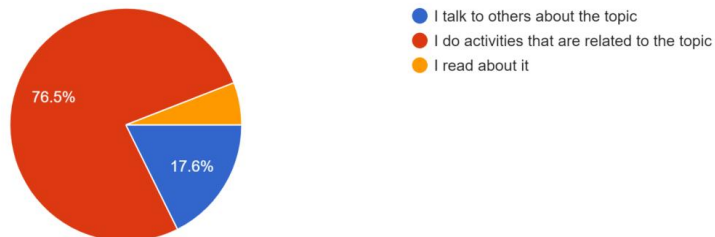
17 responses



- Strongly Agree
 - Agree
 - Neutral
 - Disagree
 - Strongly Disagree
-

Survey Results Question 19

I learn best when:
17 responses



Survey Results Question 20

How would you improve the school experience?

By studying more

Better teachers and courses

Teachers being more involved.

i wouldn't change anything a good environment

By giving teens the option to take class that help determine a career path.

by not being in school

Actually, having teachers who know how to communicate what their teaching to the students not just teachers who know how to right down some notes .

Not having to worry about getting taken out of class and disrupting my learning due to my clothes

Better between students and teachers

More mental health options

Make Literature an elective

Add a class that teaches you how to do bills and taxes

Not sure

Interactive learning

Creative learning experiences that allow teachers to interact with students.

Nah it'll suck regardless

Lingo Code for the Model

```

Lingo 19.0 - [Lingo Model - Final optimization]
File Edit Solver Window Help
[Icons]
Max = 14*y1 + 30*y2 + 11*y3 + 11*y4 + 15*y5
+ 20*y6 + 38*y7 + 26*y8 + 29*y9
+ 32*y10 + 20*y11
+ 34*y12 + 194*y13 + 37*y14 + 36*y15
+ 39*y16 + 64*y17 + 68*y18;
!Scaled variable to S-scores;
.15*E + .31*V + .34*G + .04*Nu + .08*L + .09*Ne >=.1362*y1;
.26*E + .3*V + .08*G + .14*Nu + .09*L + .14*Ne >=.2508*y2;
.2*E + .11*V + .29*G + .25*Nu + .04*L + .1*Ne >=.0985*y3;
.26*E + .25*V + .08*G + .09*Nu + .14*L + .18*Ne >=.0895*y4;
.14*E + .13*V + .08*G + .24*Nu + .19*L + .22*Ne >=.1179*y5;
.26*E + .18*V + .16*G + .05*Nu + .18*L + .18*Ne >=.1657*y6;
.23*E + .13*V + .08*G + .19*Nu + .14*L + .22*Ne >=.2974*y7;
.09*E + .06*V + .24*G + .18*Nu + .22*L + .21*Ne >=.2160*y8;
.17*E + .31*V + .08*G + .09*Nu + .13*L + .21*Ne >=.2382*y9;
.08*E + .06*V + .30*G + .26*Nu + .21*L + .1*Ne >=.2833*y10;
.13*E + .06*V + .16*G + .19*Nu + .23*L + .22*Ne >=.1601*y11;
.12*E + .32*V + .28*G + .04*Nu + .08*L + .16*Ne >=.3161*y12;
.26*E + .06*V + .16*G + .23*Nu + .18*L + .11*Ne >=.1.5943*y13;
.27*E + .13*V + .08*G + .14*Nu + .19*L + .18*Ne >=.2917*y14;
.13*E + .12*V + .08*G + .28*Nu + .23*L + .15*Ne >=.2889*y15;
.04*E + .12*V + .23*G + .22*Nu + .26*L + .14*Ne >=.3361*y16;
.14*E + .13*V + .08*G + .19*Nu + .23*L + .22*Ne >=.5023*y17;
.09*E + .19*V + .08*G + .19*Nu + .23*L + .22*Ne >=.5435*y18;
!capacity constraint 718);
14*y1 + 30*y2 + 11*y3 + 11*y4 + 15*y5
+ 20*y6 + 38*y7 + 26*y8 + 29*y9
+ 32*y10 + 20*y11 +
34*y12 + 194*y13 + 37*y14 + 36*y15
+ 39*y16 + 64*y17 + 68*y18 <= 718;

!Factor constraint (a student is made up of these factors);
E + V + G + Nu + L + Ne = 1;
E>.01;
V>.01;
G>.01;
Nu>.01;
L>.01;
Ne>.01;

!manually put all binaries in;
@BIN(y1);
@BIN(y2);
@BIN(y3);
@BIN(y4);
@BIN(y5);
@BIN(y6);
@BIN(y7);
@BIN(y8);
@BIN(y9);
@BIN(y10);
@BIN(y11);
@BIN(y12);
@BIN(y13);
@BIN(y14);
@BIN(y15);
@BIN(y16);
@BIN(y17);
@BIN(y18);

```

Lingo Output for Optimizations Model

```

Global optimal solution found.
Objective value:                130.0000
Objective bound:                130.0000
Infeasibilities:               0.000000
Extended solver steps:         104
Total solver iterations:       1862
Elapsed runtime seconds:       0.24

```

```

Model Class:                    MILP

```

```

Total variables:                24
Nonlinear variables:           0
Integer variables:             18

Total constraints:             27
Nonlinear constraints:         0

Total nonzeros:               174
Nonlinear nonzeros:           0

```

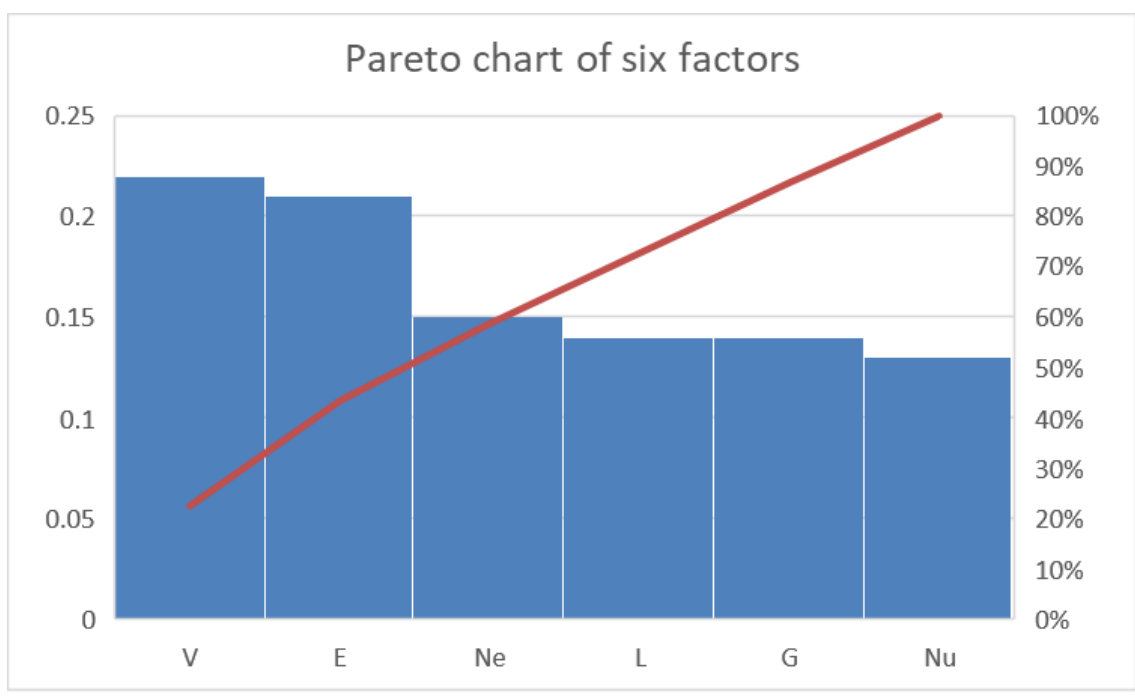
Variable	Value	Reduced Cost
Y1	1.000000	-14.00000
Y2	1.000000	-30.00000
Y3	1.000000	-11.00000
Y4	1.000000	-11.00000
Y5	1.000000	-15.00000
Y6	1.000000	-20.00000
Y7	0.000000	-38.00000
Y8	0.000000	-26.00000
Y9	1.000000	-29.00000
Y10	0.000000	-32.00000
Y11	0.000000	-20.00000
Y12	0.000000	-34.00000
Y13	0.000000	-194.0000
Y14	0.000000	-37.00000
Y15	0.000000	-36.00000
Y16	0.000000	-39.00000
Y17	0.000000	-64.00000
Y18	0.000000	-68.00000
E	0.3342391	0.000000
V	0.4486957	0.000000
G	0.1000000E-01	0.000000
NU	0.1000000E-01	0.000000
L	0.1000000E-01	0.000000
NE	0.1870652	0.000000

House Of Quality

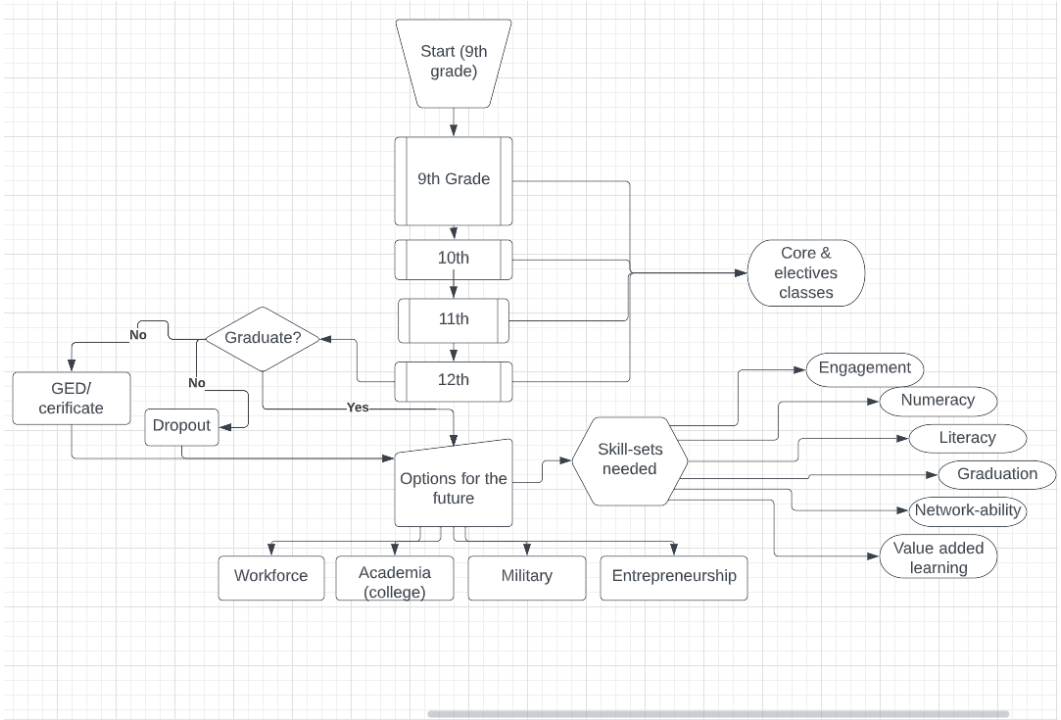
Relative Weight	Customer Importance	Customer Requirements	Functional Requirements						
			Direction of Improvement	▲	▲	▲	▲	▲	▲
			Customer Requirements	Engagement	Value added Learning	Network-ability	Numeracy	Literacy	Graduation rate
11%	7.255	Parent involvement	●	●	▽	▽	▽	○	
11%	7.254	Extracurricular activities	○	▽	●	▽	▽	▽	
14%	9.57	Course options	●	●	▽	▽	▽	▽	
10%	6.696	Course Rigor	○	●	▽	●	●	○	
12%	8.011	Diploma/GED/ Certificate	○	○	○	○	○	●	
11%	7.441	Teacher Competence	●	▽	○	●	●	○	
6%	4.128	Good Security	▽	○	○	▽	▽	○	
4%	2.375	Clean Facility	▽	▽	▽	▽	▽	○	
14%	9.446	Career planning services	●	●	●	▽	○	●	
8%	5.628	Current employment	○	●	●	●	●	▽	
		Importance Rating Sum (Impor	579.14	591.18	421.2	356.83	384.69	388.25	
		Relative Weight	21%	22%	15%	13%	14%	14%	

Correlations		
Positive	+	
Negative	-	
No Correlation		
Relationships		Weight
Strong	●	9
Medium	○	3
Weak	▽	1
Direction of Improvement		
Maximize	▲	
Target	□	
Minimize	▼	

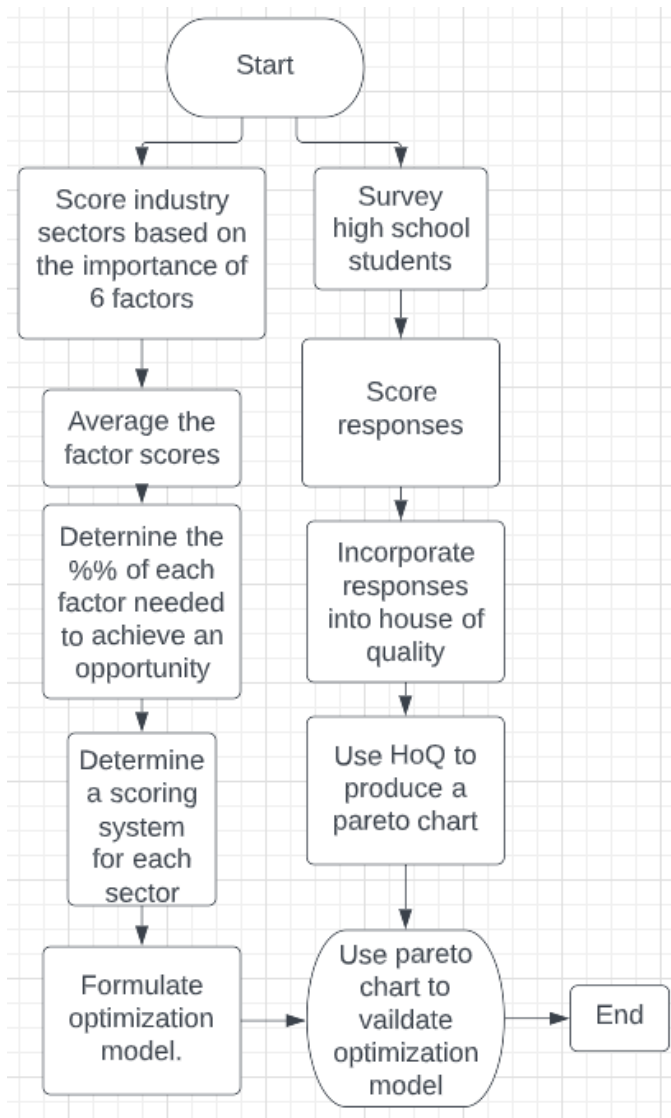
Pareto Chart



Flow Chart



Block Chart



Gantt Chart

