Prudential Math Challenge Paper 1

Resubmission

Summary

The internet is a powerful tool that has become ubiquitous in 21st century life and its influence is only growing. This leaves those without access to the internet at a disadvantage compared to those who do. In recent years, advocates have drawn increasing attention to the "Homework Gap," the number of economically disadvantaged school children without broadband internet access, and therefore do not have the same ability to perform in school as their advantaged counterparts. To address problems involving inequality, it is important to first have an understanding of the demographic breakdown of the affected population. After careful analysis of the questions posed, we came to the following conclusions:

In problem 1, the probability of selecting a Hispanic child, from a home with internet access having a household income of greater than $50,000, from a class of 28 with 68% of student households making less than $50,000, is 6.875%. To arrive at this probability, our group first separated the class data into a subset of data containing only hispanic students, then solved for the overlap between the subsets within the hispanic population that have both internet access and a household income above $50,000. The final subset overlap was then expressed as a ratio to the total population of the class to determine the probability of selecting a student that fulfills all three criteria at random.

In problem 2, using an almost identical process as the question from before. The Hispanic and White populations were both separated into their own subsets, solving for the overlap within each subset that meets all three criteria. The two overlaps were then added together and expressed as a ratio to the total population of the class to determine the probability of selecting a student that fulfills all three criteria at random, which we determined to be 11.05%.

Assumptions & Justifications

With the provided information, we made the assumption that families without school-age children are excluded in the problem because the questions asks for the probability of selecting a student that attends a school in a school district in Texas. Based on the data linked, and because the given information aligns with additional figures we found, we have assumed the district in the problem to be the El Paso Independent School District (The Texas Tribune). We also needed to know the proportion of students in each demographic that had an income above or below

$50,000. To do this, we gathered income and race data in the El Paso region (Statisticalanalysis.com). After simplifying the data to two income brackets (above or below $50,000), we determined the proportion of each person in each race and ethnicity who made up each bracket as demonstrated in the table below. We then assumed that because our data set and the given data set were a part of the El Paso region, this data would accurately represent the students in this problem and we used these numbers for our calculations moving forward.

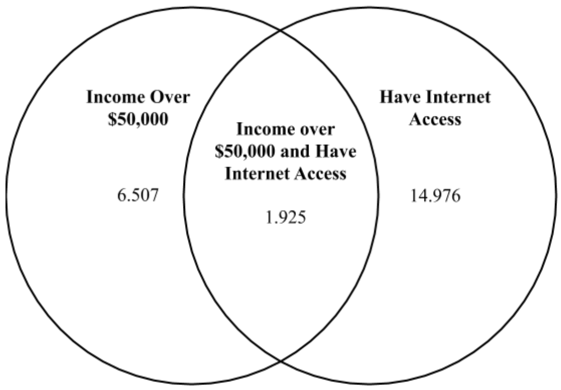
	White (Non-Hispanic)	Hispanic	Mixed	Black	Other	Asian
>50k	0.559323376	0.3602043	0.436728	0.4311975	0.3220489	0.5644169
<50k	0.440676624	0.6397957	0.563272	0.5688025	0.6779511	0.4355831
Total	1	1	1	1	1	1

Problem 1:

The problem asks us to find the probability of randomly selecting a Hispanic student who has access to the Internet and has a household income greater than $50,000 out of a class of 28. To find this probability, we calculated the likely number of students that would meet all 3 criteria and expressed it as a percentage of the total 28 students.

First, we confirmed that the classroom was a representative sample of the total population by comparing the proportion of students living in a household with less than $50,000 in annual income to the proportion of the same in the total population. According to the Texas Tribune, 69.9% of the population is considered economically disadvantaged, defined as households eligible for free or reduced lunch plans, which means their income is less than or equal to 130% of the poverty line (The Texas Tribune). The poverty line for the state of Texas is $43,430 for a family of 8 and 130% of $43,430 is $53,716. This means 69.9% of the population is economically disadvantaged, and therefore has a household income of under $53,716. We judged the difference between this number and the given 68% of the class to be an insignificant difference, and therefore used it as justification that the class was a representative sample of the total population.

Using the data provided by the Pew Research Center and information we gathered using U.S. Census data, we found that 23 of the 28 students in the class are likely to be Hispanic, 8 students are likely to be Hispanic and have a household income greater than $50,000, and 17 students are likely to be Hispanic with Internet access (Statisticalanalysis.com). We then used a Venn Diagram to visualize the distribution within the categories.



# of Hispanic Students in the Class	23.408
# of Hispanics with only Income >$50,000	6.507
# of Hispanics with only Internet Access	14.976
# of Hispanics with Income >$50,000 and Have Internet Access	1.925

$$\#\ of\ students\ who\ are\ Hispanic = (28)(.836) = 23.408$$

$$\#\ of\ students\ who\ are\ Hispanic\ \&\ have\ an\ income\ greater\ than\ 50k = (28)(.836)(.36) = 8.427$$

$$\#\ of\ students\ who\ are\ Hispanic\ \&\ have\ internet\ access = 28(.836)(.722) = 16.901$$

Both subsets within the Venn Diagram are within the subset of likely Hispanic students, therefore, the total number of students that are Hispanic should remain at 23. From here, we recognized that there is an overlap between the students with a household income over $50,000 and those who have Internet access and that overlap would be the total number of Hispanic students with a household income greater than $50,000 and Internet access. Using the following equation, we found that there are 2 Hispanic students with both an income greater than $50,000 and Internet access:

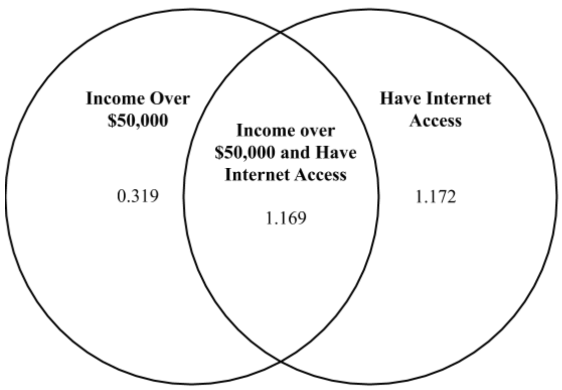
$$total - (income + internet) + overlap = 0$$

$$23.408 - (8.427 + 16.901) + 1.925 = 0 \text{ (Numbers are rounded)}$$

To find the proportion and answer the question, we divided the number of Hispanic students with a household income above $50,000 with broadband internet connection by the total number of students in the class (28), yielding the answer of 6.875%, which will be equal to the probability of randomly choosing one of those two students from the class of 28.

Problem 2:

The second problem was similar to the first, except this problem asks for the probability of the selected student being Hispanic or White, instead of only being Hispanic. The process followed is also similar, using the same assumptions about the population, solving for the white population that has the same Venn Diagram overlap found in the first problem. Once the number of students that likely fit all three criteria were found for the White population and Hispanic population, they were added together and expressed as a percentage of the total class population.



# of White Students in the Class	2.66
# of White with only Income >$50,000	0.319
# of White with only Internet Access	1.172
# of White with Income >$50,000 and Have Internet Access	1.169

# of students who are White = (28)(.095) = 2.66

# of students who are Whtie & have an income greater than 50k = (28)(.095)(.559) = 1.488

# of students who are White & have internet access = 28(.095)(.88) = 2.341

From the above Venn Diagram, we concluded that 1.169 students in a class of 28 are statistically likely to be White, to have a total household income above $50,000, and have internet access. From the previous problem, we found that 1.925 students in the class of 28 would be statistically likely to be Hispanic along with the other two criteria. To answer this problem we added those two numbers and found that 3.094 students would likely meet all of the criteria for problem 2. To find the proportion this problem asked of us, we divided this total number by the total number of students in the class and found that 11.05% of the 28 students in the class are statistically likely to be White or Hispanic, have a household income above $50,000, and have internet access.

Discussion of the Model & Research Limitations

In order to test the accuracy of our results, we examined them to see if they would fit within reasonable expectations. Given that almost 70% of the students in this hypothetical class would be eliminated due to having an income below $50,000, and a smaller but significant proportion would be eliminated with each further criteria added, it is reasonable to assume only a very small proportion of the students will meet all three criteria. In problem 2, it is also reasonable to assume that the white population will add a comparable but smaller proportion to the total because, although they represent a smaller proportion of the total population, they make up a larger proportion of the higher income population.

Our research was limited by the availability of demographic data for the El Paso region. In searching for accurate numbers, many inconsistencies and gaps were found in the data. Due to the insignificant nature of El Paso within the larger Texas demographic region, it was difficult to find data that was specific to this region. Because of this, the model produced is likely sensitive to any inaccuracies in any supplemental data sets we utilized for our calculations. As well, the model will be inaccurate if we are wrong in our assumption that the school district in the problem is EPISD, as the demographics of the given school district will be different.

Bibliography:

Barton, Jordana. *Closing the Digital Divide: A Framework for Meeting CRA Obligations*. Federal Reserve Bank of Dallas: Community Development, 2016, *Closing the Digital Divide: A Framework for Meeting CRA Obligations*.

Horrigan, John B. “The Numbers behind the Broadband 'Homework Gap'.” *Pew Research Center*, Pew Research Center, 20 Apr. 2015, www.pewresearch.org/fact-tank/2015/04/20/the-numbers-behind-the-broadband-homework-gap/.

“Household Income in El Paso, Texas (City).” *The Demographic Statistical Atlas of the United States - Statistical Atlas*, statisticalatlas.com/place/Texas/El-Paso/Household-Income.

Murphy, Ryan, and Annie Daniel. “El Paso ISD.” *Texas Public Schools*, 5 Apr. 2019, schools.texastribune.org/districts/el-paso-isd/.

Prudential Math Challenge Paper 2

Summary:

Starlink is SpaceX's ambitious plan to create satellite-based global internet infrastructure capable of providing reliable, inexpensive internet to nearly anywhere on the globe. Self-reported as the"world's most advanced broadband internet system," it is no surprise that the project carries some heavy levels of risk. This problem asks the team to assess the risk and reward of the project for SpaceX and whether or not they should proceed with the investment, assuming a $10 Billion initial investment and 9% required rate of return compounded twice per year. We found that, after filling in the remaining values in the tables, the NPV for this 10 year period is around $13 Billion and thus, SpaceX should proceed with an investment in the Starlink project due to the fact that the profit is greater than 9% of the original investment.

Additionally, the bonus question asks us to connect this possible advancement in the internet infrastructure to the digital literacy of middle school students in El Paso County that we studied during the last round. We are asked to analyze the feasibility of achieving 100% digital literacy for those aforementioned students. We have found that after analyzing all of the different factors, it is reasonably feasible to attempt to achieve a 100% digital literacy rate among El Paso County middle school students.

Problem 1:

This problem asks us to fill in the remaining values in three Cash-In Flow and Cash-Out Flow tables for a 10 year period based on the Starlink project that SpaceX is considering investing in. We are then asked to consider whether or not the project would be a good investment based on the Net Present Value (NPV) calculated using these cash-flows we solved for.

Assumptions and Justifications:

The first step in answering the problem was completing the cash-flow tables with partial data. To complete the cash-in flow tables, we noticed reported revenue per year in the provided Morgan Stanley Research Report matched exactly with the given table values listed in millions, so we made the assumption that for the missing years, the trend would continue. To complete the cash-out flow table, however, presented a much more challenging problem. The values given in the flow table do not correspond to any one line of the Morgan Stanley Research Report, meaning it must be solved for. To fill in the values of the cash-out table, we divided the cash-out flow for the given 5 years by the number of launches that year and averaged them to find the average cost per satellite launch, then multiplied that average by the number of projected launches per year as reported in the Morgan Stanley. This model, while inaccurate, is the only method to arrive at an answer we could find, using the given information. Many other approaches were explored but always lead to too many unknown variables to solve for the missing values. For example, in the Morgan Stanley report provided, the operating profit, which should represent the revenue minus costs for business, is given. When we attempted to use this to find cash-out flow, the numbers did not correlate to the given values. The reported operating profit for year one is $19 million, even though the cash-out

Cash In Flow For Satellite Internet

Cash-In Flow 1	0
Cash-In Flow 2	1,296,000,000
Cash-In Flow 3	1,759,000,000
Cash-In Flow 4	2,258,000,000
Cash-In Flow 5	2,794,000,000
Cash-In Flow 6	3,530,000,000
Cash-In Flow 7	4,275,000,000
Cash-In Flow 8	5,028,000,000
Cash-In Flow 9	5,793,000,000
Cash-In Flow 10	6,570,000,000

Cash In Flow For Satellite Launch

Cash-In Flow 1	1,503,000,000
Cash-In Flow 2	1,999,000,000
Cash-In Flow 3	2,441,000,000
Cash-In Flow 4	2,834,000,000
Cash-In Flow 5	3,182,000,000
Cash-In Flow 6	3,488,000,000
Cash-In Flow 7	3,756,000,000
Cash-In Flow 8	3,988,000,000
Cash-In Flow 9	4,187,000,000
Cash-In Flow 10	4,356,000,000

Cash Out Flow For Satellite Launch

Cash-Out Flow 1	2,000,000,000
Cash-Out Flow 2	1,700,000,000
Cash-Out Flow 3	2,127,000,000
Cash-Out Flow 4	3,073,000,000
Cash-Out Flow 5	3,543,000,000
Cash-Out Flow 6	4,018,000,000
Cash-Out Flow 7	4,491,000,000
Cash-Out Flow 8	2,540,000,000
Cash-Out Flow 9	5,437,000,000
Cash-Out Flow 10	4,549,000,000

flow is greater than the cash-in flow, meaning there should not be a profit. This means there is an unaccounted-for source of revenue that is not being reported in our cash flow value tables. Similar approaches were attempted using the NPV, NOPAT, EBIT, and profit margins, however each case presented an unknown that could not be solved for.

Discussion of Model & Research Limitations

The PVs over the 10 year period were consistently positive, indicating that the company earnings exceeded the cost. The NPV is approximately $13 billion, thus SpaceX should proceed with an investment in the Starlink project since they will receive more than their initial investment back within the 10 year time period. The model used to solve for cash-out flows is highly inaccurate, however, this method was the most reliable that would produce an interpretable result. This was largely due to the limitations in research. Many of the concepts required to do the calculations were completely new to us and were difficult to comprehend coupled with the fact that almost nothing is explained in the research report made finding the variable we were looking to solve for extremely difficult. As well, many of the given values, when we recalculated them with the numbers provided in the Morgan Stanley report, were inconsistent and further confused the process of finding which variables were able to be solved for. The model would have been much more accurate if the Morgan Stanley report had explained how it obtained the reported numbers; a detailed breakdown would have allowed for much easier recognition of variables and a less convoluted process to find the cash-out flow values.

Satellite Launch PV

PV Year 1	-475598086.1
PV Year 2	984991186.1
PV Year 3	2801554050
PV Year 4	4494609400
PV Year 5	6446972800
PV Year 6	8750660010
PV Year 7	11351952800
PV Year 8	15905779600
PV Year 9	18962784400
PV Year 10	23069111300
NPV	13069111300

Bonus Question:

The bonus question asks us to analyze the feasibility of a digital literacy program that can impact 100% of El Paso County middle school youth. Digital literacy is defined as "the ability to use information and communication technologies to find, evaluate, create, and communicate information, requiring both cognitive and technical skills" (Heitan, par. 4). The feasibility of such a program depends on the economic, technical, legal, and scheduling factors that would go into its creation.

Economically, we know that a project like Starlink, which would expand digital access around the world, would be feasible for SpaceX to enact. This will create a large advantage for El Paso schools who will not have to greatly expand their own infrastructures for internet access, only update what already exists. Additionally, from the last pool of data we were given, we know that 82.5% of all households with school aged children have high speed internet access at home. This means only 17.5% of school-aged children lack such a connection and with a program like starlink, this gap could be bridged more easily. This would allow schools to not have to worry about digital access as much as digital literacy.

For the technical aspect, teachers and students would need resources and training to improve their digital literacy. It is possible that schools could either shift or add resources into the trainings that many teachers already take part in. Legally, there are few barriers as it is perfectly acceptable for students to have access to the internet at school (as a tool for their learning) and to be taught how to properly use such a tool. Timing is the most difficult issue to manage as changes may be slow to be implemented. For one, the Starlink project has a 30 year timeline and it is unclear when exactly the El Paso region might begin to see benefits. Also teacher training takes time as it would be so new. Nonetheless, we have come to the conclusion that the digital literacy goal is feasible as long as all of the aforementioned factors continue on track as they are now.

Bibliography:

Jonas, Adam, et al. *SpaceX, Starlink and Tesla: Moving into Orbit?* Morgan Stanley, 2019, *SpaceX, Starlink and Tesla: Moving into Orbit?*

Heitin, Liana. "What Is Digital Literacy?" *Education Week*, 20 Feb. 2019, www.edweek.org/ew/articles/2016/11/09/what-is-digital-literacy.html.

Kenton, Will. "Considering a New Venture? Consider a Feasibility Study." *Investopedia*, Investopedia, 5 Feb. 2020, www.investopedia.com/terms/f/feasibility-study.asp.

Zafar, Ramish. "SpaceX Valued At $120 Billion By Morgan Stanley Due To Starlink." *Wccftech*, Wccftech, 30 Oct. 2019, wccftech.com/spacex-morgan-stanley-120-billion/.