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The effect of font type on a school's ink cost

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Summary

Ink costs are a large, recurring expense for school districts worldwide. Moreover, ink production, usage, and disposal have a detrimental effect on the environment. Decreasing the amount of ink used can therefore have a positive impact on a school district's budget and on the environment. This study identifies fonts that use ink most efficiently and estimates the amount of money a single school and a school district can save on ink by choosing efficient fonts for student handouts. From a carefully selected sample of handouts used by the school's teachers, the frequency distribution of character usage was determined. Based on these data, a document modeling an "average" school handout in terms of character frequency was created. This document was replicated with different fonts reflecting the current preferences of the teachers in the school. APVSoft APFill® Ink Coverage Software was used to estimate the ink usage for each of these font types (i.e., the percentage of a printed page that contained ink). A novel experiment was performed to verify these findings by cutting out enlarged shapes of the most frequently used letters in the most preferred fonts; the masses of these cutouts were then determined in order to estimate the relative difference in ink usage for different fonts. Based on the analysis, it was concluded that a switch to Garamond, the most efficient font, would reduce ink consumption by 24%, thereby decreasing environmental damage and saving the school district approximately $21,000 per year.

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Introduction

Printer and copier ink costs are substantial for organizations – in fact, by volume, ink is more than twice as expensive as French perfume (1, 2). Reducing the amount of ink used not only lowers the cost that an organization incurs, but also decreases the detrimental impact of ink and toner on our health and the environment (3, 4).

An organization's ink usage depends on the number and content of the pages printed. In addition, the font size and type can also potentially affect the ink usage. By changing the font type, ink costs can be reduced while, in most situations, only marginally affecting the communication efficacy.

For the English alphabet, there are more than one hundred thousand different fonts (5). Of these, a typical

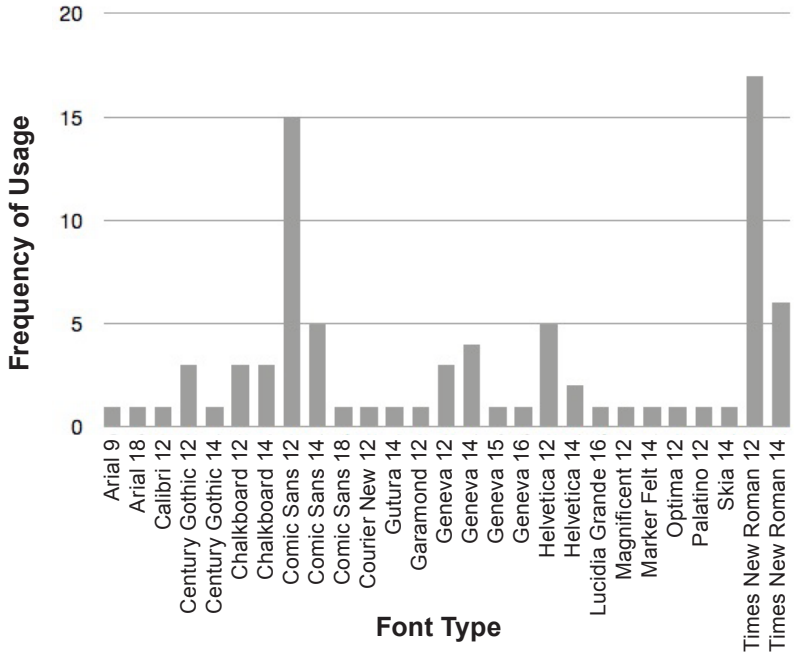

Figure 1. The table shows the results from the survey of all teachers in the school of their preferred font type and size. The most popular fonts were Times New Roman and Comic Sans.

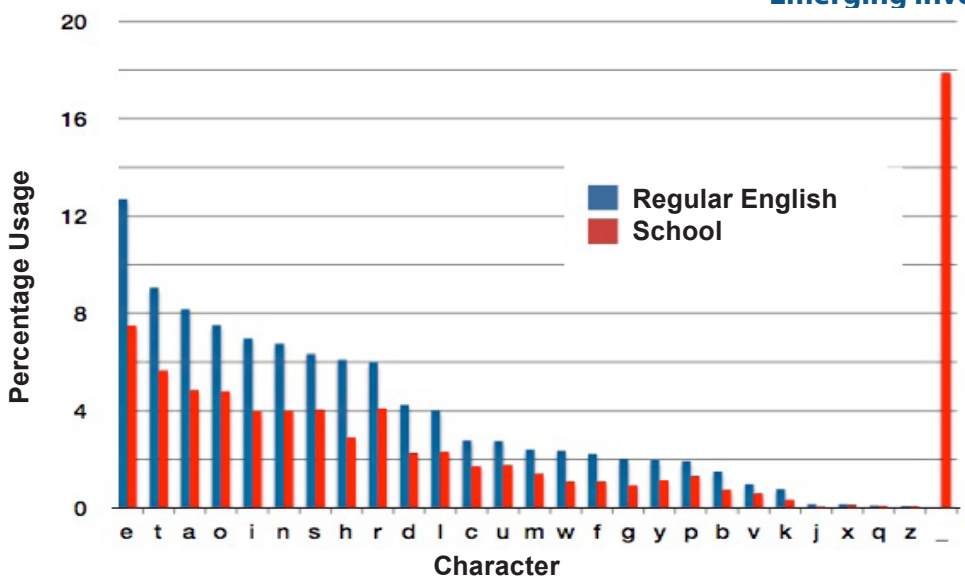

Figure 2. The frequency of characters in the documents collected at the school was compared to that of regular English.

word processor has about 200 and only about 10 fonts are used frequently, with the most popular fonts being Times New Roman, Helvetica, and Comic Sans (5). These fonts have different design characteristics. For example, some of these fonts are serif, such as Times New Roman, while others are sans-serif, such as Helvetica. Sans-serif fonts do not have "arm" and "foot" extensions on glyphs. Design characteristics in a font make it look unique. Some specialized fonts, such as 'Oops,' a "fun" font, are typically used only in specific situations, whereas a font such as Times New Roman is commonly used in more formal writing (6). While the information conveyed on a printed page does not necessarily depend on the type of font, the amount of ink used by different fonts differs because of their design characteristics.

This study investigates which font type is the most efficient in terms of ink usage and the potential cost savings at Dorseyville Middle School and the Fox Chapel Area School District in Pittsburgh, PA as a consequence of a switch to the most ink-efficient font.

Researchers at the University of Wisconsin found that switching to Century Gothic from Arial (both these are sans-serif fonts) for email printouts would save ink costs (7). Another study done by Printer.com also showed that Century Gothic was an efficient font and would save as much as 30% compared to Arial (8). Based on these studies, and considering the fact that some teachers in the school might already be using Century Gothic or font sizes smaller than 12, the following hypothesis was developed: If all teachers of the school switch to Century Gothic 12, the school will save 10% in ink costs.

Currently, the school spends $8,600 per year on ink for printing and copying, and the school district spends about ten times this amount (9). Even a small percentage reduction in the ink cost would help save the school a great amount of money. In this age of budgetary cuts, it is important that school districts save as much money as possible. This study demonstrates that savings of up to 24% can be obtained simply by switching fonts.

Results

The savings were calculated by determining what percent of a "printed" page was covered by ink using APFill® Ink Coverage Software.

Randomly sampled teachers at the school were requested to provide the handouts and documents that they printed from the school's printers. The response rate was 100%. All the teachers in the school were surveyed about their default font choice (**Figure 1**).

All the documents given by teachers were merged into one comprehensive document. A JavaScript applet was used to find the usage frequency of characters in this document (**Figure 2**). This document had a total of 82,192 characters, comprised of 104 unique characters including space and Enter. To keep the analysis tractable, the top 90th percentile of the characters were used, corresponding to approximately 75,000 total characters, reducing the number of unique characters from 104 to 21. To understand how the school's character usage compared with that in regular English, data were obtained on the character usage in regular English (10) (**Figure 2**).

A test document reflecting the frequency distribution of the 21 most commonly used characters at the school, corresponding to the top 90th percentile, was constructed (**Figure 3**). The document may look like gibberish, but was critical to the study. Different versions of this document were created—one in each of the font types and font sizes used by the school's teachers. A PDF version of

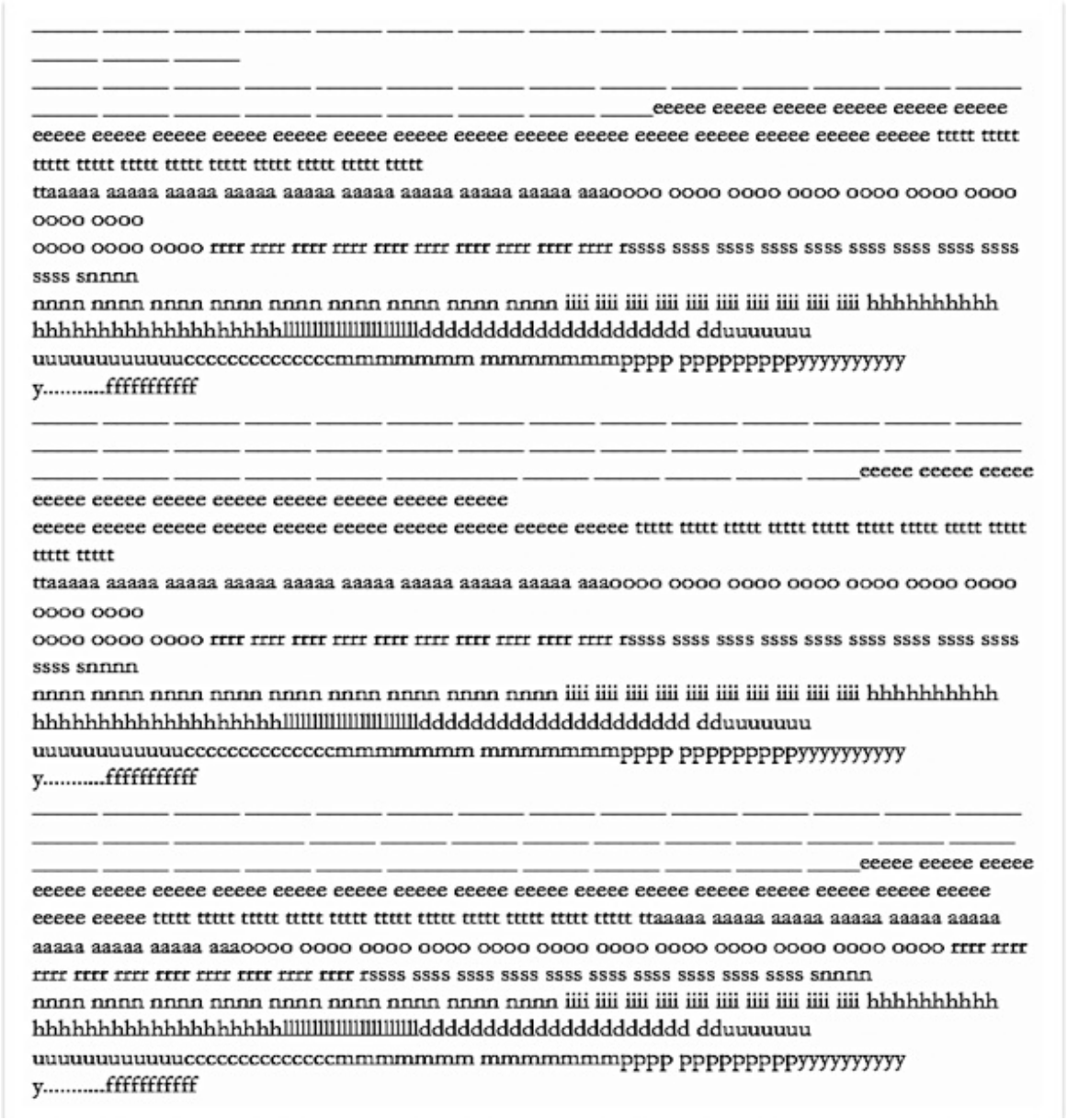

Figure 3. This test document reflects the frequency of characters in the handouts collected from the school's teachers. It is shown here in Garamond 12, but was also created in all the other tested fonts.

these documents using both a Windows-based PC and a Macintosh was created and analyzed using APFill® to find the ink coverage of each of these documents. The average of the PC and Macintosh coverage values (**Figure 4**, column 5) were used for the subsequent analysis. Some of the fonts were not available on the PC; the fonts with only one coverage observation are only compatible with Macintosh computers.

Figure 4 shows that the same content in the documents had different ink coverages and hence the ink requirements vary for different fonts. Fonts with a low coverage have low ink requirements and those with a high coverage have high ink requirements. Column 6 computes the difference in ink cost if Century Gothic 12 were to be used instead of the font currently being used. To compute these savings, the difference in the coverage if the font were switched to Century Gothic 12 was divided by the coverage of the original font. These savings were weighted by the frequencies with which the fonts are currently being used in the school to estimate the total savings. For Century Gothic 12, the estimated weighted savings turned out to be 1.59%. Therefore, the data does not have sufficient evidence to support the hypothesis that switching to Century Gothic 12 would result in savings of 10%.

However, glancing down Column 5, among all size

Font	Size	Coverage (PC)	Coverage (Mac)	Average Coverage	Savings (CG12)	Savings (TNR12)	Savings (TNR)	Savings (GAR12)
Arial	9	4.18%	3.97%	4.08%	-41.84%	-26.13%	7.98%	-9.69%
Arial	18	9.34%	9.15%	9.25%	37.48%	44.40%	5.25%	51.65%
Calibri	12	5.29%	5.28%	5.29%	-9.37%	2.74%	2.74%	15.42%
Century Gothic	12	5.51%	6.05%	5.78%	0.00%	11.07%	11.07%	22.66%
Century Gothic	14	7.27%	7.29%	7.28%	20.60%	29.40%	19.16%	38.60%
Chalkboard	12		5.52%	5.52%	-4.71%	6.88%	6.88%	19.02%
Chalkboard	14		6.64%	6.64%	12.95%	22.59%	11.37%	32.68%
Comic Sans	12	5.74%	5.74%	5.74%	-0.70%	10.45%	10.45%	22.13%
Comic Sans	14	6.88%	7.00%	6.94%	16.71%	25.94%	15.20%	35.59%
Comic Sans	18	9.16%	9.14%	9.15%	36.83%	43.83%	4.26%	51.15%
Courier New	12	5.40%	6.12%	5.76%	-0.35%	10.76%	10.76%	22.40%
Futura	14		6.61%	6.61%	12.56%	22.24%	10.97%	32.38%
Garamond	12	4.47%	4.47%	4.47%	-29.31%	-14.99%	-14.99%	0.00%
Geneva	12		6.54%	6.54%	11.62%	21.41%	21.41%	31.65%
Geneva	14		7.05%	7.05%	18.01%	27.09%	16.52%	36.60%
Geneva	15		8.12%	8.12%	28.82%	36.70%	14.90%	44.95%
Geneva	16		7.94%	7.94%	27.20%	35.26%	5.67%	43.70%
Helvetica	12	5.45%	5.59%	5.52%	-4.71%	6.88%	6.88%	19.02%
Helvetica	14	6.88%	6.72%	6.80%	15.00%	24.41%	13.46%	34.26%
Lucida Grande	16	7.43%	7.44%	7.44%	22.26%	30.87%	-0.74%	39.88%
Marker Felt	14		6.89%	6.89%	16.11%	25.40%	14.59%	35.12%
Optima	12		5.23%	5.23%	-10.52%	1.72%	1.72%	14.53%
Palatino	12	5.61%	5.66%	5.64%	-2.57%	8.78%	8.78%	20.67%
Skia	14		6.47%	6.47%	10.66%	20.56%	9.04%	30.91%
Times New Roman	9	3.75%	3.75%	3.75%	-54.13%	-37.07%	0.00%	-19.20%
Times New Roman	12	5.14%	5.14%	5.14%	-12.45%	0.00%	0.00%	13.04%
Times New Roman	14	5.91%	5.86%	5.89%	1.78%	12.66%	0.00%	24.04%
Times New Roman	15	6.98%	6.84%	6.91%	16.35%	25.62%	0.00%	35.31%
Times New Roman	16	7.43%	7.55%	7.49%	22.83%	31.38%	0.00%	40.32%
Times New Roman	18	8.58%	8.94%	8.76%	34.02%	41.32%	0.00%	48.97%
				WEIGHTED SAVINGS	**1.59%**	**12.49%**	**7.56%**	**23.89%**

Figure 4. This table contains the overall results of the project. The ink coverage of the test document was determined using APFill® Ink Coverage Software using PDF versions of the document made on both a Windows PC and a Macintosh. The average of the readings for each font was computed and used to calculate the percentage difference compared to Century Gothic 12 (to check the hypothesis), Times New Roman 12 (the most popular font), Times New Roman (no size change), and Garamond 12 (the most ink-efficient font). To determine the amount of ink the school would save by switching to one of these fonts, the saving calculations for each font were weighted by the frequency of its usage by the school's teachers. Positive savings refer to the percentage of ink and ink cost savings that would occur if the school would switch from the corresponding font in the leftmost column to the font in the title of the column. Note that some data are missing because the fonts for the corresponding operating system were not available. CG12 = Century Gothic 12; TNR12 = Times New Roman 12; TNR = Times New Roman; GAR12 = Garamond 12.

12 fonts, Garamond is the most efficient. The savings if all teachers were to switch to Garamond 12 are shown in Column 9. The estimated savings turned out to be 23.89%. Since Times New Roman was the most popular font among the teachers of the school, the savings were also computed with respect to Times New Roman 12. These savings are estimated to be 12.49%.

To verify the results from APFill®, enlarged sizes of the five most commonly used characters (e, t, a, o, r) in multiple fonts were printed on cardstock paper and cut out. **Figure 5A** shows an example using the letter "e" in Garamond font versus Comic Sans MS. The masses of these cutouts were determined. Dividing each of these masses by the mass of a full sheet of cardstock paper, the relative mass was calculated. This relative mass corresponds to the "coverage." The enlarged characters were also saved to a PDF document using both a Windows PC and a Macintosh. APFill® was used to calculate the percentage ink coverage. **Figure 5B** provides the data for the average of the three trials for each cutout (in percentages) and the APFill® values. The coverages obtained using APFill® were higher than the coverages using the mass of the cutouts with an average difference of 8.4%. Both the APFill® and cutout

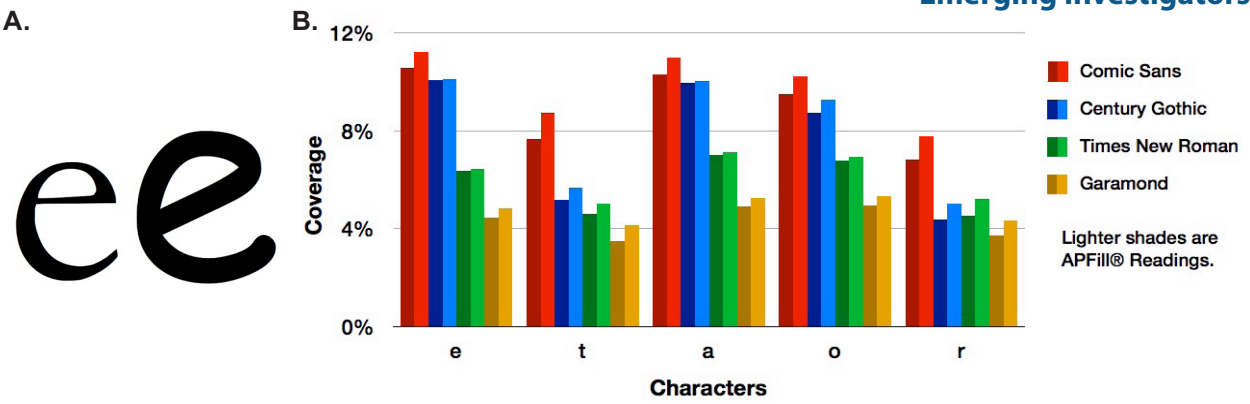

Figure 5. A. This graphic shows a visual comparison of the character "e" in Garamond and Comic Sans in the same size. **B.** This graph presents the verification of APFill® data. Three enlarged copies of the most commonly used characters were printed on heavy cardstock paper in four significant fonts: Comic Sans MS, Century Gothic, Times New Roman, and Garamond. The three trials for each letter were massed and the average was computed. The relative mass was calculated by dividing by the mass of a full cardstock sheet. The process was repeated on both a Macintosh and PC to create PDF documents rather than printouts for analysis by APFill®. The percentage ink coverage readings for both the PDFs were averaged and are compared in the graph above. The APFill® readings, shown above in the lighter shaded bars, were consistently between 6 and 12 percent greater than the cutout percentages (an average of 8.4% greater). Both the Garamond readings and cutouts indicated that it was the most efficient font.

calculations supported that Garamond was the most efficient.

If all the teachers of the school district were to shift to Garamond 12, the estimated annual savings in ink costs would be 23.89% of the current ink costs of $86,788 (for total ink costs, see **Figure 6**). This corresponds to an estimated savings of $20,733 per year for the school district. The estimated savings of the school would be about 10% of this amount. Similarly, if all the teachers of the school district were to shift to Times New Roman 12, the savings would be approximately $10,500 per year. These savings were based on the APFill® calculations. Since the average difference between the coverages obtained by the APFill® and cutout methods was only 8.4%, it is expected that the predicted savings would be similar if the cutout method was used.

Discussion

Keeping font size invariant, the investigation shows that Garamond is the most efficient font. Times New Roman, which is the most popular font among the school teachers, is the second most efficient font. Although the results are inconsistent with the proposed hypothesis, the savings calculated for Garamond and Times New Roman are more than what was predicted for Century Gothic. Since the hypothesis was based on conclusions in the study done by the University of Wisconsin, it is possible that the incorporation of character frequency specific to Dorseyville Middle School was a reason for difference in the results.

While the study primarily focused on the "direct" cost savings to the school, reducing ink usage results in "indirect" cost savings due to lower environmental impact (4). The direct cost savings occurs at the ink usage stage, which is what was studied. However, indirect cost savings occur because of lower effluent discharge during ink production and less adverse impact on the environment during ink disposal.

The estimated savings by switching to Garamond are large. However, there are two limitations of this study. First, in computing the weighted savings it was assumed that each teacher prints the same number of documents. This is a reasonable assumption since the class sizes are roughly the same. Yet, it might be useful to incorporate the actual number of pages printed by each teacher in the weighting step. Second, a judgmental cluster sampling method was used by first choosing the school within the school district and then randomly selecting teachers at the school. The school is thus a cluster chosen for investigation, and the results were extrapolated to the school district. In order to determine the savings for the school district, using a random sample of teachers across the entire school district might be better.

While visual observations make it apparent that different fonts require different amounts of ink for the same characters, it was not obvious how to compute the ink requirement differences. The first approach was to draw each character on a fine grid and then determine the area covered by the character. However, this approach was extremely cumbersome and did not seem scalable. Some research led to a package called APFill® that could determine the ink coverage of any PDF document. It was used to calculate the percentage of a printed page that would be covered by ink. As noted previously, APFill® coverages were higher than the coverages obtained using the cutouts method. The reasons for this difference are not immediately obvious. If the cutout method determines the coverage more precisely than

Serial #	Toner Model #	Estimated Annual Usage	Industry Average Price ($)	Annual Cost ($)
1	96a	24	$109.99	$2,639.76
1	27x	28	$143.00	$4,004.00
1	05a	56	$89.00	$4,984.00
1	82x	12	$223.00	$2,676.00
1	49x	18	$145.00	$2,610.00
1	64a	4	$172.99	$691.96
7	61x	16	$143.99	$2,303.84
8	13x	12	$101.99	$1,223.88
9	12a	4	$179.99	$719.96
10	53x	12	$164.99	$1,979.88
11	70a	8	$68.49	$547.92
12	71a	8	$68.49	$547.92
13	72a	8	$68.49	$547.92
14	73a	8	$68.49	$547.92
15	11x	12	$229.99	$2,759.88
16	38a	44	$172.99	$7,611.56
17	42x	4	$248.99	$995.96
18	51x	4	$238.99	$955.96
			TOTAL PRINTER COST	$38,348.32
			ESTIMATED TOTAL COPIER COST	$48,439.98
			TOTAL INK COST	$86,788.30

Figure 6. Ink cost is a substantial part of an organization's budget. The school district investigated in this study shows that the school district has a total ink cost of about $87,000 along with its breakup by toner model (10). By reducing the amount of ink used by changing to an ink-efficient font, this expense can be reduced.

the APFill® method, then the savings computed in this paper would need to be lowered by about 8%. Else, if the APFill® method gives more accurate results, no adjustment is necessary to the savings.

The most frequently used character by teachers was the underscore character—which was rarely used in regular English documents. Teachers use the underscore to create lines for writing in exams. Such differences might be one reason that the conclusions are different from the ones made by the University of Wisconsin (7). Additionally, the University did not compare all of the fonts and sizes used at the school.

The number of underscore characters needed to make a line depends on the font type and size. In the study, however, the number of underscore characters in the sample document was invariant of font type. For larger fonts, this difference can marginally exaggerate the savings because the number of underscore characters needed to complete a line would be fewer. However, if a teacher would add an additional line for the answer because the extension to the end of the line from the end of the question is short, then the number of characters used for a larger font could in fact be higher.

It is important to note that, aside from the 26 fonts tested, there are other commonly used fonts for regular English documents. Some could be even more ink-efficient than Garamond. An extension of this study could apply these methods to all the 200 or so fonts available in a typical word processor. Testing all existing fonts (numbering more than 100,000) would require some automation.

In addition, fonts may be chosen with a specific purpose in mind (e.g. aesthetics), but posters and other graphical design in which font type could have meaningful impact would usually be printed on a color printer. Color toner ink costs for printing were not tested in this study.

Another related way of saving ink is the following: when an assignment is photocopied from a book, a black border in the periphery is sometimes printed. This black border gets copied, leading to a large wastage of ink. "Whiting out" the black periphery would further reduce the ink usage in the school district. This impact would be in addition to what was investigated in this study.

Finally, it is important to note that while schools in the United States are likely to be similar to the school tested, the usage of handouts and therefore ink usage is likely to be different at overseas schools. However, the study does demonstrate that the effect of shifting to Garamond would be positive wherever English handouts are used. It would be useful in a future study to investigate the potential savings worldwide by shifting to Garamond and to determine which fonts are more ink-efficient in other scripts.

A recommendation is that teachers of the school district switch to Garamond and Times New Roman in size 12. Since about 20% of teachers already use Times New Roman, no change in font will be needed, making this recommendation easier to implement. Implementing this recommendation would save the school district between $10,500 and $21,000 every year.

Methods

Several types of data were needed for checking the hypothesis. These data were (1) sample handouts used by teachers in the school, (2) fonts preferred by the teachers in the school, (3) current ink costs, and (4) ink requirements for different fonts.

Sample documents used by teachers in the school. To determine which characters were used by teachers in the school, a random sample of teachers was determined using the random number generator available in Microsoft Excel. These teachers spanned all three middle-school grades and comprised 10% of the school's teachers. The data collection was done during a week when there were no school holidays or half days. Some teachers gave hardcopies of all the handouts that they used during the week under consideration, while others gave electronic copies. The handouts included

homework, packets, study guides, tests, and similar documents. The response rate for this phase of data collection was 100%.

Fonts preferred by teachers in the school. At the time of the study, there were 106 teachers in the school excluding those who were on leave. They were asked to respond with their preferred fonts. This survey had a response rate of 82 teachers, or 77%. Since these results were used to also extrapolate to the entire school district, this sampling technique is classified as judgmental cluster sampling.

Current ink costs. The ink costs at the school consist of costs that are incurred for printing and copying. Printing accounts for about 40% of the total ink costs. There are six schools in the school district, and the school ink costs are approximately 10% of the total annual ink costs of $87,000 for the school district. This information was collected from one of the school administrators.

Ink requirements for different fonts. To quantitatively evaluate the percentage of ink on a printed sheet, APFill® Ink Coverage Software was used. The documents for each font were analyzed by APFill®, and these percentages were used to calculate the savings if a user switched from that font to a) Century Gothic 12, b) Times New Roman 12, c) Times New Roman (without a change in size), or d) Garamond 12. These savings were weighted by popularity of the fonts. To verify the accuracy of APFill®, the masses of the cutouts were used. Enlarged copies of the five most commonly used characters were printed three times on thick cardstock paper and the masses of the cutouts were determined. Next, the masses of three blank sheets of cardstock paper were determined and averaged. The cutouts' masses were divided by the blank sheet's mass to calculate the relative mass, which would represent the percent of ink coverage. The same documents that were used to print the large cutouts were exported to a PDF document using both a Windows PC and a Macintosh. Each character (one per page) was analyzed by APFill® for the percent ink coverage. These APFill® percentages were compared with those for the cutouts to verify APFill®'s accuracy.

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