The Environmental Impact of Growing Numbers of E-books in Libraries

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ABSTRACT: E-books are becoming a significant proportion of scholarly literature used for research at academic institutions such as Boston College. For the purpose of this study, we define an E-book as digitally formatted scholarly literature, a category of reading that consists of journals, article collections, and other peer-reviewed literature that is didactically written and only accessible by membership to a database. The environmental impact of transitioning away from paper books towards electronic readings is not well understood and so developing information on the subject will be useful to Boston College's Libraries as they continue to add to their scholarly literature collections for student researching purposes. We found that the majority of environmental waste for both E-books and paper books originates before the intended audience receives the reading, namely from production. However, paper books contribute significantly more waste during distribution, making them less environmentally sound overall. Generally speaking, if a user accesses more than 33 E-books on a device, they will have offset the total carbon footprint of their device, thus being more environmentally efficient than reading the book's print counterpart. We surveyed Boston College students and discovered that most students have utilized E-books through BC libraries and are in favor of increasing BC's E-literature collection. We also gathered library data from Boston College librarians on printing, scanning, and E-book/E-reader usage to properly understand student habits. We found that printing numbers have increased in recent years and that students tend to check out paper books from the library more than they do tablets. This might be due to the fact that the BC Libraries house and offer significantly less electronic literature than they do paper books or that there is a lack of awareness of the E-reading resources available. Faculty also promote the use of hard copy material. We recommend that BC Libraries invest in more E-books and E-readers. We also recommend that faculty members inform their students of the environmental implications associated with paper books versus E-books and promote the use of digital texts and online submission sites rather than hard copies.
KEYWORDS: E-books, environmental efficiency, library

Introduction

Technology is beginning to permeate every aspect of modern day life. Because it disseminates information in a more streamlined and accessible manner, we now assume it will be accessible to us at all times and in all places. E-books and E-readers are examples of the progress made toward relaying information with such expediency. Sales of E-Books and the number of devices capable of displaying them (E-readers) are rapidly increasing. Since Amazon launched the Kindle in 2007, E-books sales have increased dramatically (GPI, 2011). According to the Green Press Initiative, in 2007 and 2008, E-book sales totaled about $30 million and $60 million respectively. Then in 2009, they skyrocketed to a whopping $169.5 million. In 2010, Apple released its first generation iPad (Apple, 2011) and together, the Kindle and the iPad now dominate the E-reader market. A recent survey revealed that 47% of E-book readers use the Kindle and 32% use the iPad (GPI, 2011). In a 2010 study performed by the Book Industry Study Group (BISG) 25% of E-book owners stated that they would purchase fewer printed books, 15% stated that they do not purchase any printed books, and 9% stated they would not purchase a printed book even if the book they wanted was not available as an E-book (GPI, 2011).

Despite this recent increase in electronic E-books and E-readers, as we move forward it is necessary to question the environmental and social implications of such technological advancements. E-books are becoming a significant proportion of scholarly literature used for research at top universities like Boston College. The environmental impact of this change is not well understood and having this information will be useful to Boston College's libraries as they continue to collect scholarly literature to aid future student research. According to Chris Conroy, the Associate University Librarian for Collections, Boston College spends $1.5 million every year on new texts for the library. A new question has surfaced as to how much of this money should be invested in paper books versus E-books.

For the purposes of our study, an E-book is defined as a piece of digitally formatted scholarly literature, which consists of journals, article collections, and other peer-reviewed literature that is didactically written and only accessible by membership to a database. This does not include textbooks or novels because they are only available through publishers as rentals and thus would not be economically sound. Access to peer reviewed literature on the other hand can be purchased permanently. We aim to assess and compare the environmental impacts of paper

books versus E-books. We also aim to collect and analyze student preferences and trends at Boston College to determine whether or not investing in more E-books would be a desirable change on campus.

Therefore, we will address three main research questions:

1. What are the environmental impacts of E-books, and are they greener than traditional paper books?
2. Do Boston College students prefer to use E-books or traditional paper books?
3. Should Boston College Libraries invest in more E-books?

Literature Review

Before analyzing the environmental impact of increasing numbers of E-books specifically at Boston College, we wanted to understand the environmental impact of E-books as a whole. It is particularly relevant especially in comparison to the impacts of the traditional publishing industry. We will assess different statistics that show the increase in popularity of E-readers and the predicted impact of this trend. We will then apply this to the trends of Boston College students.

First, let us address the publishing companies' waste in creating paper books. The Green Press Initiative (GPI) and the Book Industry Study Group commissioned a report on the environmental impacts of the US book industry and found that in 2006 the book industry harvested approximately 30 million trees and the average sold book has a carbon footprint of 4 kilograms of CO_2 (GPI, 2011). Another study was conducted two years later and according to the GPI in 2008 the US book and newspaper industries resulted in the consumption of 125 million trees and concludes that the average book produces 7.46 kilograms of CO_2; this figure includes books that are not sold and have to be returned and disposed of by the publisher (Hutsko, 2009). Textbooks are especially wasteful, as they result in 10.2 kilograms of CO_2 (Ritch, 2009). It also concluded that paper represents seventy five percent of the publishing industry's carbon footprint and twenty six percent of landfills waste (Ritch, 2009). In addition to the paper consumption, books and newspapers are incredibly water and energy consumptive. They produce 153 billion gallons of wastewater annually (Ritch, 2009). The process of getting a book to the reader's hands involves the consumption of raw materials, the paper production, printing, shipping, transportation, and disposal. Not all books even make it to a readers home;

between 25 to 36 percent of books printed do not sell and are returned to publishers to be disposed of (Hutsko, 2009). Ink also is problematic as it makes up one percent of print emissions by releasing toxins into the air and water (Ritch, 2009).

The two leading E-readers are Amazon's Kindle and Apple's iPad. Amazon was the first to release a successful, groundbreaking E-reader coming out with the first generation Kindle in 2007. Paired with it's online E-book purchasing capability, sales began to skyrocket and other companies began to emulate their design model and release their own devices. The most successful competitors were Barnes & Noble's Nook and Apple's iPad. Suddenly, the platform for reading had changed and so people began to wonder if this was environmentally a step forward as well.

Analyzing the impact of E-books proved itself to be trickier than that of publishing companies, because their impact is so strongly correlated to user behavior and manufacturing demand (GPI, 2011). Two environmentally influential user trends are that the greater the number of books read per E-reader and the lower frequency of E-reader replacement correlates to greater environmental efficiency (GPI, 2011). Another limitation to data is that not all companies are willing to release their production information, so it is hard to assess their actual impact; Amazon has neglected to release any information about what materials go into producing Kindles (Hutsko, 2009). In fact, Apple is the only manufacturer to release a comprehensive environmental impacts report about their E-reader, the iPad (GPI, 2011). The statistics provided and information we derive from this narrow iPad use to only include E-reading functions; when an iPad functions in this manner it only requires about 3 watts of energy (Apple, 2011).

Table 1. Power Consumption for iPad 2 and iPad

Power Consumption for iPad 2 (Wi-Fi + 3G)

Mode	100V	115V	230V
Sleep	0.46W	0.41W	0.45W
Idle—Display on	3.10W	3.08W	3.16W
Power adapter, no-load	0.07W	0.07W	0.09W
Power adapter efficiency	80.9%	80.8%	79.9%

Power Consumption for iPad (Wi-Fi + 3G)

Mode	100V	115V	230V
Sleep	0.42W	0.43W	0.41W
Idle—Display on	2.97W	2.96W	3.04W
Power adapter, no-load	0.07W	0.07W	0.09W
Power adapter efficiency	80.9%	80.8%	79.9%

Apple indicates that the greatest sources of greenhouse gas (GHG) emissions from the iPad come from production, usage, and transportation (Apple, 2011). Apple is focused on creating recyclable products that are materials efficient, which can be cited by an 18 percent reduction in materials between the iPad 1 and 2 (Apple, 2011). Apple reports that the average

iPad will release 130 kilograms of greenhouse gases in it's lifespan, 30 percent of this carbon footprint being attributed to energy use (GPI, 2011). The GPI also released "Findings from the US Book Industry: Environmental Trends and Climate Impacts" Report, which claims the average printed book releases 4 kilograms of GHG in it's lifespan (GPI, 2007). Combining these statistics indicates that if an iPad user read 33 books then they will have offset the total carbon footprint of their device.
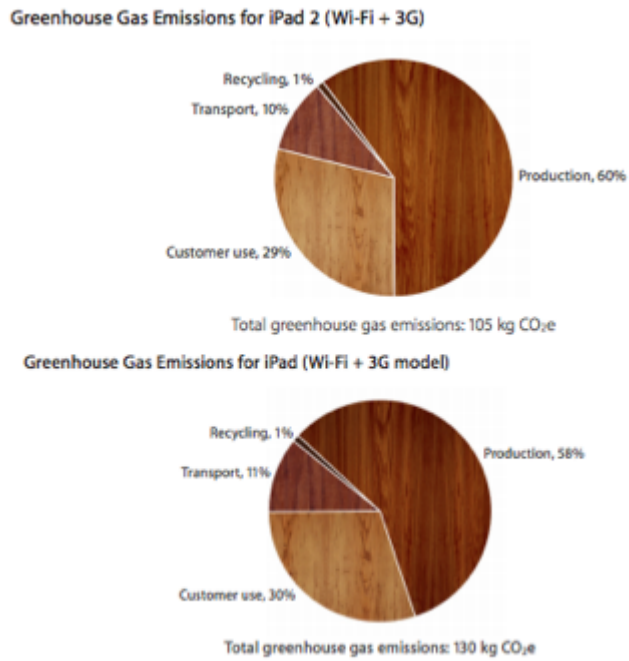
Greenhouse Gas Emissions for iPad 2 (Wi-Fi + 3G)

Recycling, 1%
Transport, 10%
Production, 60%
Customer use, 29%

Total greenhouse gas emissions: 105 kg CO₂e

Greenhouse Gas Emissions for iPad (Wi-Fi + 3G model)

Recycling, 1%
Production, 58%
Transport, 11%
Customer use, 30%

Total greenhouse gas emissions: 130 kg CO₂e

Figure 1. GHG Emissions for iPad 2 and iPad

Kindles have been assess separately by external analyses for their environmental waste. According to the GPI, the carbon footprint of Kindles is marked at 168 kilograms of GHGs and equated to 42 paper books carbon emissions (GPI, 2011). Cleantech Group, LLC claims that the
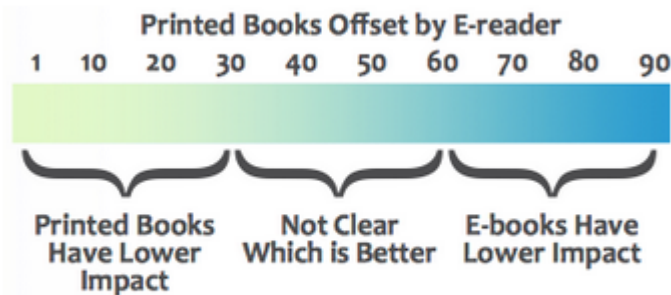
Printed Books Offset by E-reader

1   10   20   30   40   50   60   70   80   90

Printed Books Have Lower Impact
Not Clear Which is Better
E-books Have Lower Impact

Figure 2. Comparison of Print and E-readers

GHG emissions of a Kindle are offset by reading 22.5 paper books (Ritch, 2009). They juxtapose that purchasing 3 E-books per month for four years, equivalently 144 E-books, produces about 168 kilograms of CO2 by a Kindle compared with 1074 kilograms that would go into producing the same number of paper books (Ritch, 2009). A basic Kindle has the storage capacity to prevent the emissions of 11,185 kilograms of GHG and an at capacity Kindle DX could offset 26,098 kilograms (Hutsko, 2009). Amazon CEO Jeff Bezos is quoted as saying that the average Amazon online book purchase was 1.65 E-books for every paper book resulting in each E-reader offsetting 22.5 book purchases each year and netting 9.9 billion kilograms of CO2 being prevented in a four year period (Ritch, 2009).

Table 2. E-reader Units Sold Per Year

	2009	2010	2011	2012
E-reader units sold per year (average of below forecasts)	2,763,667	5,060,667	9,136,333	14,438,000
Forrester	2,700,000	5,000,000	9,700,000	13,000,000
iSuppli	3,591,000	7,182,000	12,209,000	18,314,000
Insight Media (est.)	2,000,000	3,000,000	5,500,000	12,000,000
Cumulative e-readers sold	2,763,667	7,824,333	16,960,667	31,398,667
Books purchased per unit each year	36	36	36	36
Ratio of e-books purchased to physical books	1.6:1	1.6:1	1.6:1	1.6:1
Actual physical books offset per year per e-reader	22.5	22.5	22.5	22.5
Average CO2 emitted per physical book in kg	7.46	7.46	7.46	7.46
CO2 prevented by each e-reader device per year	167.85	167.85	167.85	167.85
Kg of CO2 prevented due to e-book sales each year	463,881,450	1,313,314,350	2,846,847,900	5,270,266,200

Sources: iSuppli, Forrester, Insight Media, Industrial Design Consultancy, Babcock School of Business, U.S. Environmental Protection Agency, Green Press Initiative, Amazon, Cleantech Group analysis

Cleantech Group also addresses the materials invested in E-book and paper book production. They claim that physical books require an input of 78 times the water needed to produce each E-book (Ritch, 2009). They note that further information about mining, energy use, and E-waste is limited due to Amazon neglecting to provide data and information about its practices (Ritch, 2009). Addressing transportation variations, they claim that the Kindle's emissions are equivalent to 15 books bought at the store versus 30 books purchased online, resulting in 60.2-306 kilograms (168 kilograms average) of GHG emissions savings for the same book (Ritch, 2009). They further claim that any usage over these 23 books will only compound and increase the environmental benefits of E-readers. The last words of warning that Cleantech Group provides is that all of these environmental savings are contingent on the publishing company recognizing the industry transition and producing less paper books in response (Ritch, 2009).
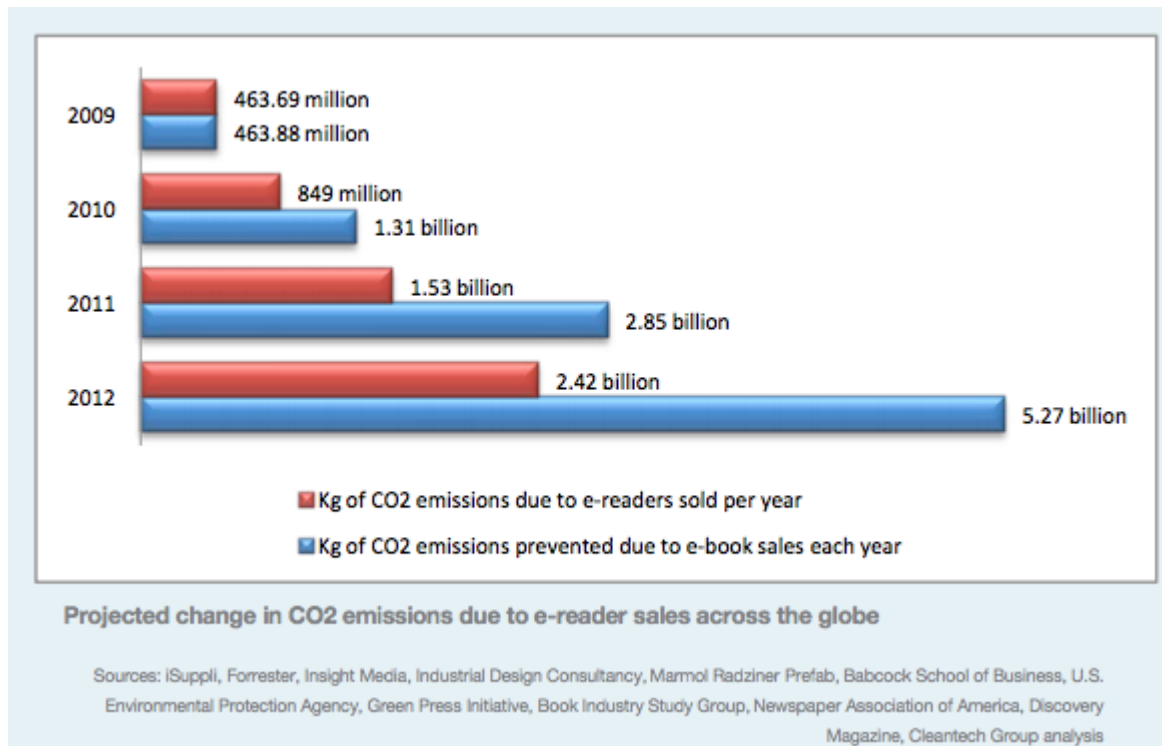
Figure 3. Projected Change in CO2 Emissions Due to Global E-reader Sales

An alternative, more general study by Goleman and Norris published in the New York Times places the impact of E-readers due to fossil fuels, water use, and mineral consumption payback equivalent to 40 to 50 books; but places the impacts due to global warming as equivalent to 100 books (Goleman and Norris, 2010). They break down the supply chain assessing the impacts of materials, manufacturing, transportation, reading, and disposal E-readers compared with paper books. They claim that one E-reader requires the extraction of 15 kilograms of minerals and an input of 79 gallons of water, whereas a book requires 0.5 kilograms of minerals and 2 gallons of water. In manufacturing an E-reader uses 100 kilowatt hours of fossil fuels netting 30 kilograms of carbon dioxide compared with a book which needs 2 kilowatt hours producing 1/100th of the GHG emissions of E-readers. Transportation impacts are much more variable as it depends how far a book needs to travel to get into your home. Reading produces an interesting statistic, as reading by a light at night uses more energy than it takes to charge an E-reader, but obviously reading by daylight is more energy efficient. Finally, they address disposal and conclude that there are no perfect ways to recycle E-readers. When done illegally, workers in developing countries dismantle the pieces and are exposed to a myriad of toxins. Organized recycling is still potentially hazardous for workers and local communities.

Then if either an E-reader or book ends in a landfill to degrade or be incinerated, they will both emit GHGs and groundwater contamination. The consumers are responsible for confirming recycling claims when returning items to the manufacturing company and it can be noted that not all E-books provide internal recycling program options (GPI, 2011).

Methods

Student Survey

As discussed above, E-books are more environmentally efficient than traditional paper books when a single electronic device has at least a certain number of texts on a device. This is also provided the E-book is not printed and that there is no hard copy available, because to do so would defeat the purpose of lessening the environmental impact of the E-book. In addition to understanding the environmental impact E-books and their increased usage at Boston College, it is important to understand the needs and wants of the student body. The researchers created a 15-question survey through the online platform SurveyMonkey to assess the general consensus on campus. Through involvement in extracurricular activities, the researchers were able to distribute the survey to 72 undergraduate students across all four years and four schools within Boston College. In order to maintain anonymity, the team chose not to ask for gender or any other identifying information like names or Eagle ID numbers. This sampling reflects an accurate representation of the parties that will be affected by the recommendations of this research.

1. Do you own a tablet (Kindle, iPad, etc.)?
2. Do you own a personal computer (laptop or desktop)?
3. What electronic device do you use to read electronic scholarly literature (books, journals, articles, etc.)?
4. Within a semester, how often do you use library resources for academic research (online journals, paper books, etc. - NOT including course reserves textbooks)?
5. Have you ever scanned and printed materials relevant to your academic assignments (research, reports, papers, etc.)?
6. What is your preference for reading scanned documents?
7. Why is this your reading preference?
8. If a piece of scholarly literature was not assigned in class, how often do you independently expand your research through Ebooks provided by the library?
9. How many times throughout your Boston College career have you utilized a scholarly Ebook?
10. While at BC approximately what percentage of your professors have advised you to refrain from using electronic devices (cell phone, tablet, computer) in the classroom?
11. How many of your professors have advised you to consult BC's library database for outside research?
12. To what extent would you recommend the library to invest in more scholarly Ebooks?
13. Class year?
14. School within Boston College?
15. Which category does your major best fall into?

**Figure 4.** *Electronic survey questions (answer options not included)*

The first two questions not only assess the student usage of electronic devices, but also the need for an increased number of tablets in the library, should BC libraries decide to invest in more E-books. The answer options for the third question on student usage for reading e-literature include tablet, personal computer, both, or neither. Again, this assesses the need for more tablets within library resources, and also indicates the specific type of e-journals to which BC should subscribe (i.e. formatted for tablets or for computers). Question five analyzes the frequency with which students utilize library resources for academic research, which is useful when determining the validity in investing in more E-books. The next three questions relate to scanning usage in particular, and whether students prefer to read scanned documents in print or in paper. The researchers also felt it was important to understand why students held their particular preferences, and provided options of "easier access, easier to annotate, gentler on the eyes, easier to transport/travel with, and other (with the option for specification)." These questions are useful because they provide information regarding the environmental efficiency of paper versus electronic books. If students frequently make hard copies of digital literature, or second copies of paper books, the environmental impact of both methods is increased, and therefore, this data becomes extremely important. Questions 8 and 9 assess how often students

utilize library E-books independently and how often they have used E-books in general, and is again advantageous when recommending investment in an increase in the e-library of Boston College. The next question is addressing the fact that some professors at this school do not allow students to use electronic devices in class, which would require students to obtain print copies of the academic resources needed for those classes. Question 11 is useful in determining how many professors contribute to student E-book usage through BC's libraries. The next question asks the respondents how much they would recommend the library investing in more E-books, which is helpful in understanding the overall desire among students on campus. The last three questions ask students to provide general information about themselves, which is necessary in order to ensure an accurately structured and diverse sample.

Results

Student Survey

This survey provided results that are extremely helpful in recommending BC library investment in more E-books. All students said they own a personal computer, but only 27 of the 72 (37.5%) respondents own tablets. We determined that 73% of students use computers to read electronic scholarly literature, 17% of students use both a tablet and a computer, and 10% of students use neither a tablet nor a computer to read E-books. No student said they use a tablet exclusively for E-books. We also found that most students use library resources for academic research regularly, with 36% of students saying they frequently use such resources within a semester (4 or more times) and 39% saying they occasionally use library resources within a semester (2-3 times). 17% of students said they use library resources rarely, only once within a semester, and 8% of students said they never use these resources. Most students have scanned and printed materials relevant to academic assignments, with 76% saying they have and 24% saying they have not. We found that 76% of students prefer reading scanned documents in print, while 24% prefer reading such documents electronically. Figure 5 and Table 3 explain the reasoning behind such preferences.
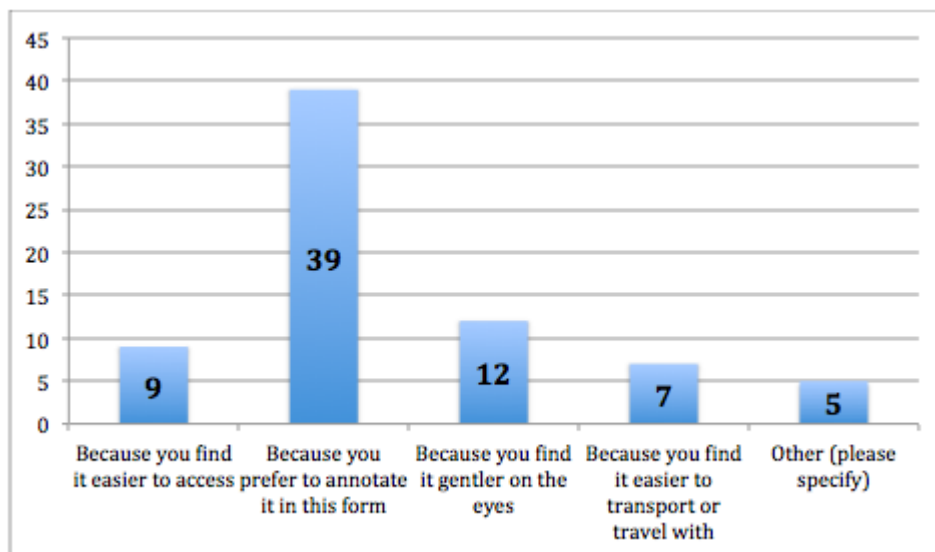
Figure 5. *Graph of the answers to Question 7: Why is this your reading preference?*

**Table 3.** *Explanations of the answer selection "Other" for Question 7 of the student survey.*

Other Respondent Explanations
All of the above
It's easier to transfer the bibliography to RefWorks or EasyBib
Electronic copies do not take up physical space and are more transportable (I can have multiple journals in one tablet for the same weight)
Because its more environmentally friendly, I don't print unless I have to
I prefer to read in print, but it is just so much easier to access electronic copies and such a hassle to print that I end up doing the bulk of my reading on electronic devices

Most (44%) students never independently expand their research through E-books at the BC library, though 37% rarely do (1-2 assignments), 14% of students occasionally do, and 6% of students frequently independently expand their research. When asked how many times throughout their Boston College career students have used a scholarly E-book, 56% of students said they had used an E-book 1-2 times, 15% said 3-5 times, and 29% said they had used an E-book 6 or more times. When asked what percentage of professors had advised students to refrain electronic devices in the classroom, two students (3%) said all of their professors, 20 students (28%) said 75% of their professors, 28 students (39%) said 50% of their professors, 21 students (29%) said 25% of their professors, and 0 students said none of their professors. We determined

that many professors advise students to consult BC's library databases for outside research, with 5 students reporting 100% of their professors, 20 students reporting 75% of their professors, 24 students reporting 50% of their professors and 19 students reporting 25% of their professors. Only 4 students reported that none of their professors had advised them to consult BC's library databases for research. Overall, most students are in favor of Boston College libraries investing in more E-books, with 21% of students highly recommending more E-books, 25% recommending, 47% somewhat recommending, and 7% not recommending an investment in more E-books. This survey included 43 seniors, 8 juniors, 16 sophomores, and 5 freshmen. There were 51 students in the College of Arts and Sciences, 9 students in the Carroll School of Management, 3 students in the Connell School of Nursing, and 9 students in the Lynch School of Education who participated in this survey. When asked what category their major(s) best fit into, 16 students said the Humanities (English, History, Foreign Language, etc.), 17 students said Natural Science (Biology, Chemistry, Physics, Environmental, etc.), 19 students said Social Science (Psychology, Sociology, Communication, etc.), 7 students said Mathematics, 1 student said Fine Arts/Theatre, 8 students said Education, 3 students said Nursing, and 15 students said Business/Management/Economics.
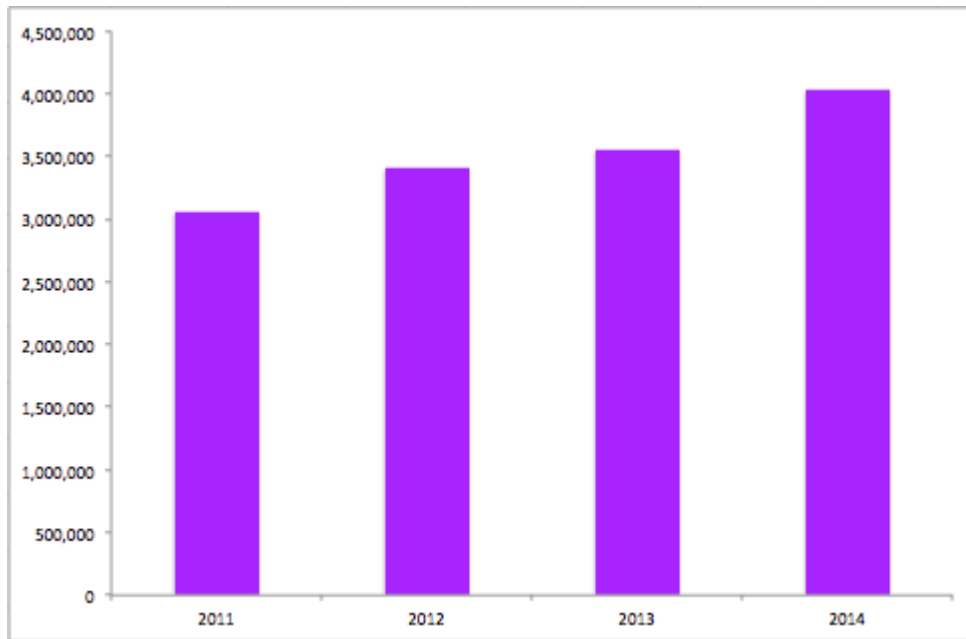
Boston College Libraries Results

Paper Usage in O'Neill Library
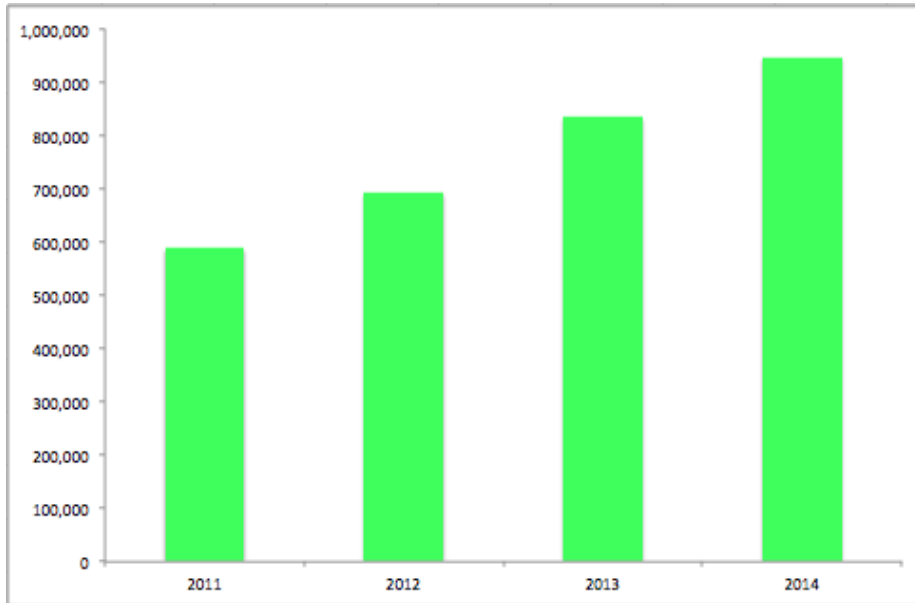
Figure 6. Total number of pages printed annually from 2011 to 2014 on the 1st Floor of O'Neill Library.
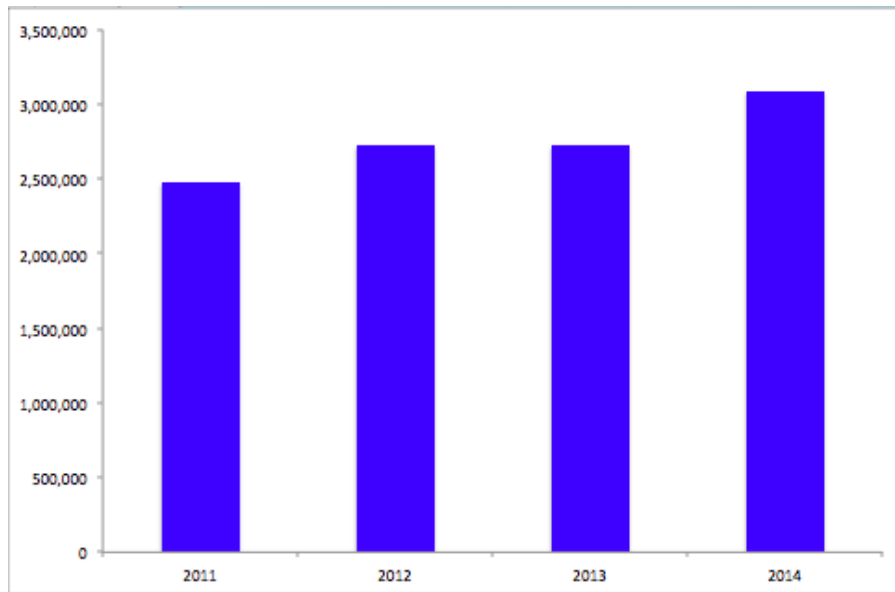

Figure 7. Total number of pages printed annually from 2011 to 2014 on the 3rd Floor of O'Neill Library.

Figure 8. Total number of pages printed annually from 2011 to 2014 on the 1st and 3rd Floors of O'Neill Library combined.

Figures, 6, 7, and 8 show a consistent and general increase in printing in O'Neill Library from 2011 to 2014. In 2011, the total number of pages printed on the 1st and 3rd floors were 588,384 and 2,475,051 respectively, totaling 3,063,435 printed pages for that year. In 2012, the total number of pages printed on the 1st and 3rd floors were 691,984 and 2,722,401 respectively, totaling 3,414,385 printed pages. In 2013, the total number of pages printed on the 1st and 3rd floors were 833,623 and 2,724,043 respectively, totaling 3,557,666 printed pages. Finally, in 2014, the total number of pages printed on the 1st and 3rd floors were 946,418 and 3,089,878 respectively, totaling 4,036,296 printed pages.

Printed Pages Versus Scanned Images in O'Neill Library
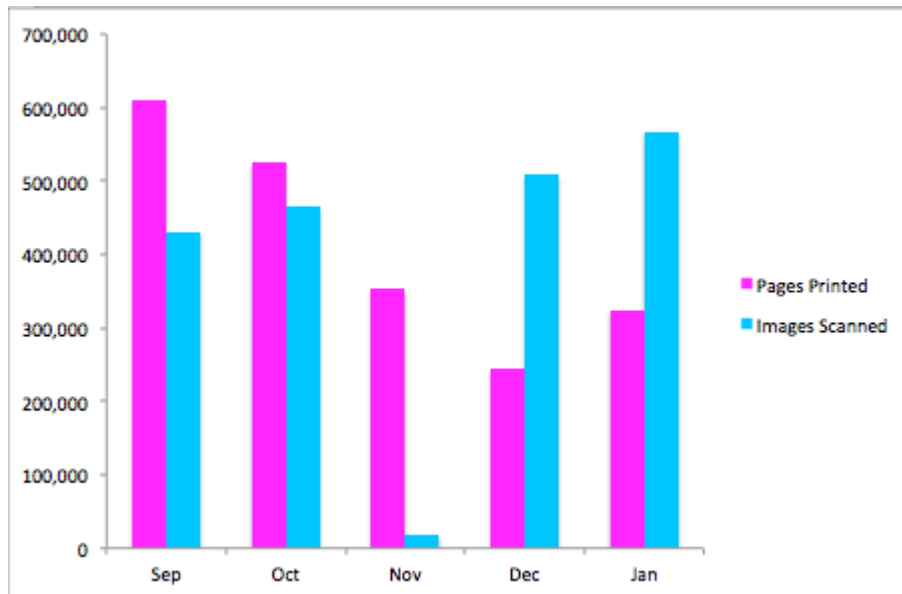
Figure 9. Number of pages printed in O'Neill Library (1st and 3rd floors) compared to the number of images scanned for September - December of 2014 and January of 2015.

Figure 9 reveals the fluctuation in both printing and scanning numbers over the course of the school year. According to the data, Boston College students do not consistently tend toward one or the other in O'Neill Library. Students appeared to print significantly more than they scanned in September, October, and November, but appeared to scan more than print in December and January. In September of 2014, students printed a total of 609,663 pages and scanned a total of 431,062 images. In October of 2014, students printed a total of 524,786 pages and scanned a total of 464,850 images. In November of 2014, students printed a total of 352,855 pages and scanned a total of 19,310 images. In December of 2014, students printed a total of 244,087 pages and scanned a total of 509,386 images. In January of 2015, students printed a total of 324,929 pages and scanned a total of 567,487 images.

O'Neill Library Holdings and Check Out Information

O'Neill Library currently houses 2,286,576 paper books and owns 20 iPads that are available for lending. In addition, Boston College has permanent access to a total of 528,311 E-books. From September 1, 2014 to April 14, 2015 88,047 paper books were checked out from O'Neill Library while Apple iPad's available to students were checked out a total of 1,197 times.

iPad Usage Data and Future Directions

When we asked Connie Strittmatter, the Head of Access Services at Boston College about the library's plan to increase the number of iPads we lend in the future, she informed us that 20 seems to be the right number for individual circulations. However, they do receive many requests from student groups, departments on campus, and faculty to check out multiple iPads. To address this, the library has already purchased 10 additional iPads that will become loaner packs. By the 2015 fall semester, O'Neill Library will have two loaner packs containing 5 iPads each that will be available to these various groups.

We also inquired about what becomes of the old iPads once the library decides to upgrade the devices. Ms. Strittmatter informed us that last summer, 10 1st generation iPads were taken out of circulation. The library kept a few to have around in case they needed extra, but seven were donated to the Montserrat Program on campus and the remaining devices were disposed of. It was a relief to hear that so many of the outdated iPads are recycled on campus and are still utilized.

Student Survey Analysis and Discussion

The results showed that while all students own personal computers, only a little over 1/3 own tablets. This is significant because it shows that E-books that are only accessible in tablet form would be less popular, since most students do not even own tablets. Additionally, most of the students surveyed use only computers to read E-books and only 17% said they use both. So despite the fact that 27 students said they own tablets, only 12 said they use both a computer and tablet for reading. This further supports the notion that E-books are preferable when their format is accessible on laptops.

Another significant finding is that while 76% of students have scanned library materials, they prefer to read these materials in paper format. This is problematic due to the fact that what

makes E-books more environmentally efficient is the amount of text on the device in comparison with the paper text. However, if students prefer to print E-books rather than use them in digital form, this negates the purpose of the green argument in favor of e-literature.

We also questioned students as to several habits that professors at Boston College practice which either encourage or discourage E-book usage. Almost all students reported that they had at least one professor who had banned electronics during their time at BC. This is problematic because it discourages environmental efficiency when it comes to electronic literature. When students are forced to bring printed versions of online articles to class because it is against policy, it can lead to hundreds of wasted pages over the course of the semester. Furthermore, some students reported that none or only 25% of their professors advised them to consult BC Library databases for academic research. While the majority of students had at least half of their professors recommend BC databases, if more professors were to inform students about available online resources, it could be argued that students would be more likely to use them.

Next, we analyzed the E-book usage data that students reported in several questions of the survey. The majority of students reported that they use library resources at least twice a semester, which indicates that most students enjoy the regular access to both paper and online information. However, more than half of the students said they had used an E-book five or fewer times throughout their time at Boston College. This could be due to the fact that more than a third of the respondents are between freshman and junior year students, so they have not had as many semesters to report usage. The most important conclusion, however is that 95% of students at least somewhat recommend that the library invest in more E-books. Despite the fact that half of the respondents had only utilized a scholarly E-book two or fewer times, most students do want access to them- it is clear that there is a changing attitude towards E-books, even if the behavior is taking longer to catch on.

Finally, the fact that the majority of respondents were seniors is not significant because the researchers are also in their final year at Boston College and sent the survey to friends and teammates. The team also believes that having a majority of older respondents is helpful because it allows for a more accurate representation of E-book habits at this institution, since these students have had the most experience.

Boston College Libraries Analysis and Discussion

Our findings indicate that there has been a consistent and general increase in printing in O'Neill Library over the years. From 2011 to 2014, the total number of pages printed annually increased from 3,063,435 to 4,036,296 (a difference of 972, 861 additional pages). It appears that Boston College students do not plan to stop printing paper anytime soon. Perhaps this is due to the fact that many professors still require their students to hand in hard copies of assignments. Even if professors do allow their students to submit their assignments via email or through the university's Canvas website, many prefer to read and grade them in their hard copy from and end up printing them anyway. Paper production companies must then account for these rapidly increasing printing numbers by harvesting more trees and inevitably producing more carbon (GPI, 2011).

The data also revealed a fluctuation in both printing and scanning numbers over the course of the school year. We found that Boston College students did not consistently tend toward one method from September 2014 to January 2015. It would be inaccurate to assume that students simply do not have a preference between printing or scanning (or are equally likely to print and scan the same document) because these two methods are used in different circumstances. Students appeared to print significantly more than they scanned early in the semester (September, October, and November). This could be due to the fact that students are more dedicated to their work around this time and are diligent paper printers. On the other hand, students appeared to scan more than print toward the end of the semester (December and January). This could be explained by the fact that many students are applying to various winter jobs and internships around this time and need to scan transcripts, resumes, and other important documents.

Boston College's O'Neill Library houses significantly more paper books (2,286,576) than it does E-books (528,311). The data recovered from September 1, 2014 to April 14, 2015 revealed that 88,047 paper books had been checked out of O'Neill Library while the Apple iPads were only checked out a total of 1,197 times. For the iPads to have provided students with access to the same number of books, they would have had to download 74 E-books onto each tablet that was checked out. This is an extremely high and unrealistic number, which means that students either prefer to check out paper books or are simply unaware that the library lends iPads.

Overall, we found that the E-readers and therefore E-books being used at Boston College Libraries are environmentally sound, especially in comparison to paper books. The university plans to invest in more iPads in the future and recirculates and donates its old tablets. Another thing to consider is that if the BC Libraries were to invest in more E-books, they would not come with a hard copy of the journals. This means there is no paper involved. E-books are accessible 24/7 on tablets, the library desktops, and personal laptops. They are convenient and provide users with easy searchability while conserving library shelf-space. The only obstacle the librarians have ever faced with their E-book collection is that sometimes users are turned away from an online chapter because there is no "multiple user" option. However, if this is the case they will simply purchase another copy, which is financially expensive but has no environmental cost.

Limitations

BC Libraries Limitations

One major limitation we faced was not being able to check how many E-books Boston College members keep on their E-readers. O'Neill Library does not track what students and faculty members download onto the iPads. When they are returned, the librarians restore the iPads to the original settings. Unfortunately, this severely limited our ability to perform a proper environmental cost-benefit analysis in terms of this E-reader usage in relation to paper books. This also prevented us from investigating whether people were downloading E-books onto these tablets, or if they were simply downloading other documents such as novels, newspapers, magazines, etc. We also had no access to information regarding the types of documents people were printing or scanning in the O'Neill Libraries. We had no way of knowing if the pages being printed or if the images being scanned were necessarily E-books. The printing and scanning data we collected simply allowed us to quantify student preference and trends regarding the possible transition from paper books to electronic materials.

It was also impossible for us to find a figure for E-book usage on campus because there is no central information house for this data. Rather, each iPad individually collects the usage information. Due to this, we were limited to data that showed us how many times an iPad was checked out, rather than how many E-books were downloaded onto each iPad.

General Limitations

It is necessary to consider the possibility that E-reader and tablet owners might read more books simply due to the ease and convenience of downloading. This means that every book read on the device would not necessarily correspond to a printed book that is offset (GPI, 2011). In addition, in examining the environmental impacts of one paper book and one E-reader/tablet, for the purposes of our study we are assuming that the reader would have to either purchase a new printed book once and not share it with anyone else or would read E-books on an E-reader and only use the E-reader for reading books. If the consumer shares a printed book with others, buys some used printed books, or borrows printed books from the library, the environmental impacts of the paper book would need to be adjusted accordingly. Similarly, if the E-reader is used for other activities (watching video, browsing the internet, checking email, or reading magazines and newspapers) we cannot say that all of the energy used is on E-books and the environmental impacts would need to be adjusted accordingly as well. More research is needed on typical E-reader user behavior in terms of time spent reading E-books versus other activities (GPI, 2011).

Recommendations

From our research and analysis, we believe the Boston College Libraries should continue to invest in more E-books and E-readers. E-books at Boston College are the more environmentally efficient option and provide students with the convenience and ease of accessing information from their personal laptops or tablets. However, despite the environmental advantages, we still face the challenge of student and faculty preference toward hard copies. We recommend that the BC Libraries not only invest in more E-books and E-readers (in this case it would be more Apple iPads), but we strongly encourage the librarians and other faculty to raise awareness on campus of the environmental implications associated with printing and the manufacture and distribution of paper books versus electronic texts. Yes, students tend to print more each year and check out more paper books than they do tablets, but this is due to the fact that a) they are unaware of the environmental consequences of paper manufacturing and book distribution, b) they are provided with 1,000 free pages to print each year, c) they are unaware that the library lends tablets, and d) the library owns and offers significantly fewer E-readers and E-books than it does paper books. Faculty should be heavily encouraged to take advantage of the online Canvas submission site and should be dissuaded from banning electronic readers in class.

We believe that there should be a library informational event as a part of freshman orientation that introduces and explains all of the libraries' E-literature resources (in addition to other valuable information about the libraries). We also believe that the administration should vastly reduce the amount of free printing offered to curb students' current habits. If 100 pages were allowed each semester rather than 500, then students would still have enough to print necessary assignments, but this restriction would deter excessive printing. If professors, librarians, and other BC faculty made an effort to reduce their own as well as their students' printing, Boston College Libraries and the university as a whole could greatly reduce their carbon footprint.

Conclusions

The Boston College Libraries are in a transitional state as they respond to the technological climate of the information sector. Their current and anticipated investment in more E-readers and E-books illustrates their response to the modernization of reading. This transition to electronic texts is especially beneficial because there is a more sustainable allocation of resources throughout their overall production and distribution. So long as BC continues to recycle their E-readers, rather than contribute to E-waste, the environmental impact of these devices is much less than that of printed texts.

If Boston College follows our recommendations to increase their E-reader and E-book selection, then they are following a general global trend towards digitalization. This trend has and will continue to alter many modes of information distribution as it condenses the availability of physical books. Popular opinion believes that libraries are transitioning their role on college campuses as places to socialize or to work, rather than to research or to take out books (Posner, 2012). O'Neill Library epitomizes this role as a student center, as students can be found studying together at any time of day or night. This shows that as digitalization shifts the location of books to an online platform and off of the shelves that libraries will not be barren, but will still play an integral role in student life. The overall role of libraries though in modern society will continue to evolve as digital reading continues to improve and become more standard.

As libraries transition, the shift to increased E-readers will also change the way we interact with and experience texts. As we transition from paper books to reading off of screens, we lose some of the tactile and responsory senses that we use to absorb information (Jabr, 2013). Prolonged screen time is more mentally exhausting than reading paper, which limits the amount

of information we are able to internalize in one sitting (Jabr, 2013). This along with the fact that reading on a screen alters the way the brain navigates and perceives text can contribute to lower reading comprehension (Jabr, 2013). E-readers also alter the way we interact with readings, as one is able to jump around the text and search for keywords; this can have both a positive and negative influence on student habits, as it can reinforce bad reading habits or it could increase efficiency due to convenient searchability.

Despite this modernization and society's transition towards digital learning, Boston College students remain attached to printed documents. This student preference is the greatest challenge to the environmental soundness of electronic reading. However, despite these student trends, many people choose the convenience and accessibility of electronic texts and as E-reading continues to improve, its usage will grow (Hirtle, 2002). Thus, the library should do all that it can to trim printing paper consumption, for if the current practices continue neither hard copy books nor E-books will result in greater environmental efficiency.

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