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Visual Communications Journal
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Editor's Note

by Daniel Wilson, D.I.T. • Illinois State University

Published in this Spring 2011 *Visual Communications Journal* are four studies on various aspects of the visual communications discipline that may be of use to educators. The VCJ is an excellent and unique source of research-based information on industry trends, technology, and contemporary curricular matters. Following is a summary of the content in this issue.

An RIT contingent of Twyla J. Cummings, Patricia Sorce, and Ashley Walker present their findings on gender equality in the printing industry. As with other studies from various industries, the RIT team found that female pay lags male income levels. Within their study are recommendations to educators.

E-commerce use by printing companies is fast growing and many graphic communications programs are adding digital media and Web technology curricular content. Devang Mehta presents his findings on the relationship between the frequency of Web site modification and business performance, providing a link between the technology and business functions of Web technology use.

As the lithographic process has transitioned to computer-to-plate technology and digital printing continues to grow, little is heard of photographic film production for plate imaging. However, many in industry and education still use photographic imagesetters to make high

contrast film intermediates for flexography and screen printing. Adam Burke and I present research on alternative technology: using an inkjet printer to produce films. The technology has developed into a viable alternative to photographic film.

Colleagues Edward J. Lazaros and Thomas H. Spotts of Ball State University surveyed members of the Indiana printing industry to determine the perceived importance of including Six Sigma content in their printing management curriculum. As companies integrate quality processes, educators should be preparing graduates who can understand the principles of quality management and who can help companies put these principles into practice.



Producing Film Intermediates with Inkjet Technology

by Adam A. Burke, M.S. • Daniel G. Wilson, D.I.T. • Illinois State University

Even with the proliferation of CTP (Computer-to-Plate) technology, film intermediates are still used in some print-production facilities to produce photographically-imaged lithographic and flexographic printing plates, as well as for stencil imaging in some screen printing facilities. In the flexographic printing process, photopolymer plates imaged with film negatives are still the dominant platemaking method in the flexographic industry. It is estimated that 20% of the flexography industry uses CTP technology worldwide, with only 400 plus installations in North America and the rest of the flexographic plates still requiring film production (Bodwell, 2006; Hershey, 2006).

The traditional way of making film separations for plate exposure is by photographic means, requiring an imagesetter for exposure and a photographic processor for the development of film through activator and stabilizer chemical solutions (Foundation of Flexographic Technical Association [FFTA], 1999). There is another option. Today, film separations can also be made by inkjet technology, made possible with specialized third-party RIPs. This technology has been used successfully for making film positives to image screen printing stencils for several years, and has mainly been marketed to the screen printing industry, where screen frequencies are quite low. However, over recent years the technology has improved and higher screen frequencies are now possible.

Many graphic communications laboratories at the high school and college level have imagesetters and photographic processors installed for film production. Most of these facilities also have access to an inkjet device that could be used to image highly adequate, high-density film separations for lithography, flexography and/or screen printing. This might allow instructors to eliminate equipment (imagesetter and photographic processor) and photographic chemistry, while increasing valuable space and reducing maintenance time and costs.

Research Problem

This research set out to test the suitability of inkjet-generated film for imaging flexographic photopolymer plates at Illinois State University's Print Media Lab. Film separations of a test form was output to both an imagesetter and to an inkjet printer for comparison, at both an 85 lpi and

at 133 lpi screen frequency. Photopolymer plates were made from each set of films and test forms were printed on press. Finally, the line work, dot structure, and tonal ranges achieved were analyzed after taking microphotographs of select areas of the test form. Through the process of testing the film, some of the idiosyncrasies of working with inkjet film were discovered. This information may be helpful to those looking for an alternative to photographic film.

RIPs for Inkjet Separations

RIP technology is the key to creating film separations from an inkjet device. Companies offering RIP software for inkjet film separations include Wasatch, AccuRIP, EFI, Proof Systems, & ImageLine, Inc. The basic concept behind this technology involves printing an extra thick layer of photo black ink onto the surface of transparent film, which results in a suitable density to use for plate exposure. These RIPs may be used with any of a wide range of inkjet printers on the market and, like many imagesetter RIPs, can generate both amplitude-modulated screens (traditional halftones) and frequency-modulated screens at various resolutions.

To achieve optimal film quality, some advance testing needs to be done to determine the best RIP settings. The RIP's controls allow the user to balance the optimal resolution of their inkjet device with the quantity of ink deposited by the inkjet head. The resolution of inkjet heads vary depending upon the inkjet printer model, but common dpi values include 720 dpi, 1440 dpi, and 2880 dpi. There is a relationship between the printer dpi and the top end screen frequency that will reproduce well. As a general rule, producing screens with higher printer dpi settings tend to yield more gray levels in the halftone. In other words, higher dpi generally allows for higher screen frequencies, while maintaining gray levels and reducing banding problems. The relationship between printer dots per inch, halftone screen frequency, and gray values is expressed:

$$\# \text{ gray values} = (\text{printer resolution}/\text{screen frequency})^2 + 1$$

Therefore, a 720 dpi inkjet printer used to generate an 85 lpi screen frequency = $(720/85)^2 + 1 = 143$ gray levels. However, RIP technologies extend the gray levels through super cell functions, an algorithm that groups like size

halftone dots into clusters, and then varies the dot sizes within the cluster to extend the visual tones well beyond the simple mathematical relationship expressed above. This means that selecting a lower dpi (like 720 dpi) can still provide the screen frequency desired without banding problems (Eschbach, 1999).

For film output, the ink quantity deposited by the inkjet nozzle must be controlled by the inkjet RIP. Inkjet ink volume is measured in picoliters, which is equal to one trillionth (or 10^{-12}) of a liter. Inkjet printers typically use ink droplets that measure somewhere between 2 and 25 picoliters, with smaller droplets enabling higher resolution images. By increasing the picoliters deposited per droplet, a higher density (Dmax) can be achieved on the film. However, increasing the deposit might also adversely affect dot fidelity, particularly at high screen frequencies and resolutions. A common optical density recommended for flexographic film is around a 4.0, but the Dmax of inkjet films that tested in this research study did not exceed 3.0 (FFTA, 1999). However, a 3.0 Dmax was high enough to image our flexographic plates without UV light exposing non-image areas.

Another variable that the RIP software must control is the speed at which the ink is deposited. When so much ink is deposited, more ink setting time is required between each pass of the inkjet head over the media. The RIP software allows the user to specify a delay. Also, once the film is completely imaged, more time than usual is required to allow the film to dry so that it can be handled without damage. This drying delay can also be increased via the RIP software interface.

Regardless of the RIP software used, the general process of determining the best RIP settings for a given inkjet printer works in the following way:

1. Choose the inkjet device. The RIPs marketed for producing film separations support most inkjet models on the market.
2. Make initial settings for printer resolution, screen frequency, ink deposit in picoliter, and inkjet head pass delay.
3. Output a grayscale test strip using these initial settings.
4. Examine the film with a loupe and also measure the Dmax with a transmission densitometer. If the Dmax of the film is lower than 3.0, increase the ink deposit in picoliters. Also, if there is streaking or dot plugging, alter the inkjet head delay.

5. Re-output the test strip and re-measure the Dmax. Repeat step 4, if necessary.
6. Once a 3.0 Dmax is achieved, create a linearization curve. This would be done in much the same way as a linearization curve on an imagesetter: by measuring the dot percentages in each patch along the gray scale with the transmission densitometer and entering those values into the linearization utility of the RIP software.
7. Output the test strip again and verify linearization.

Testing Methodology

The research involved outputting the same test form to both inkjet film and imageset film. Inkjet films were produced using a Wasatch SoftRIP SP 6.5 and an Epson 7800 inkjet printer (Figure 1). An Agfa Acuset Imagesetter with a Rapidline 17 processor was used for producing the imageset films. Both devices were optimized and linearized. The inkjet film settings were for both an 85 lpi and a 133 lpi screen frequency, with a printer resolution of 1440 x 1440, achieving a 3.0 Dmax. The imageset films were output to 85 lpi and 133 lpi screen frequencies at a resolution of 2540 dpi. Both sets of film were used to image flexographic photopolymer plates. Cosmolight NS photopolymer plates and an Anderson Vreeland orbital flexo plate processor was used for plate exposure and processing. These two sets of plates were then run on the same press with the same settings. The test form included a

The test form utilized in the experiment.

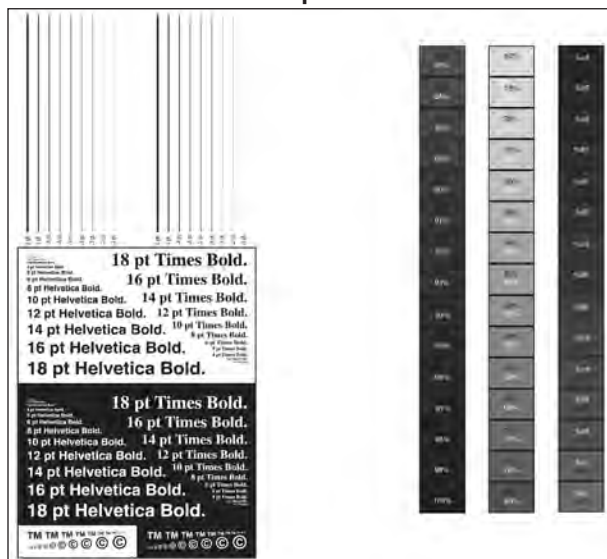


Figure 1

range of highlight and shadow dot patterns, as well as type of various point sizes and fine lines. The plates were run on a Comco Cadet Model 700 narrow web press with 600 cell count anilox rolls and a semi-gloss Raflasilk RP51 label stock.

For analysis and comparison, microphotographs were taken of the films, plates, and printed reproduction in select areas. The analysis includes measurements and observations on tonal ranges, dot formation, and overall suitability for various applications.

Testing Results

Linework. The Dmax of the films made by inkjet was adequate to image our photopolymer plates. The ability of the inkjet films to image fine lines and text was quite good. For inkjet film generated plates, line weights up to 0.5 points were held on the plate and common minimum font sizes of 6 points and 8 points reverse also held on plate. These line weights and font sizes also could be reproduced on press (Figure 2). Imageset films also reproduced the common font sizes well, but were able to carry a finer line weight of 0.25 points. While microphotographs show some artifacts on the line edges for the inkjet film, these did not reproduce in the printed reproduction, and we saw no discernable difference with the unaided eye.

A comparison of line and type reproduction for film, plate and print.

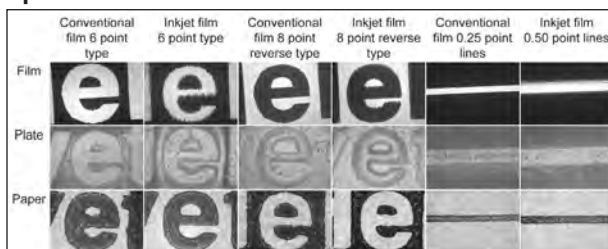


Figure 2

Shadow dots. Some limitation of the inkjet film showed up in the ¾ tone to shadow areas of the tonal scale, though the limitation was unlikely to affect print quality greatly. Table 1 shows the range of dots imaged adequately to our plate for each of the films. For the inkjet film at a 95% dot size, it appears that not enough ink can be accurately targeted and layered for these very small dot formation (that is, shadow dots at high screen frequencies). These dots appeared to have critically low densities and therefore did not block the UV light adequately during exposure, resulting in a 100% solid where 95% dot

formations were desired (Figure 3). The shadow dots for the inkjet film with an 85 lpi screen frequency held up better than the 133 lpi screen frequency. As these dots are larger in diameter, so there is more area available for the inkjet nozzle to deposit ink.

Table 1: A comparison of smallest and largest reproducible dots on plate and press after dot gain.

	Smallest highlight dot reproduced on plate and press (after gain)	Largest shadow dot reproduced on plate and press (after gain)
85 lpi inkjet film	5% plate, 8% press	80% plate, 95% press
85 lpi imageset film	2% plate, 5% press	80% plate, 96% press
133 lpi inkjet film	8% plate, 12% press	75% plate, 93% press
133 lpi imageset film	2% plate, 3% press	2% plate, 3% press

However, due to dot gain, shadow dots that are this small (95%) are not needed on the plate to reproduce 95% shadow dots on press. Conditions on the Comco press typically result in up to a 28% dot gain in midtone areas and about 15% in ¾ tone to shadow areas. The test form was made with linearized film, with no cutback curve (this means that a 95% dot on film and plate will fill in on press: 95% + 15% gain = 100%). Therefore, to print a 95% dot on press, the film and plate would require approximately an 80% dot (80% + 15% gain = 95%). Therefore both conventional film and inkjet film produced printed reproductions with little limitation in the shadow region.

A comparison of shadow dot reproduction for film, plate and print.

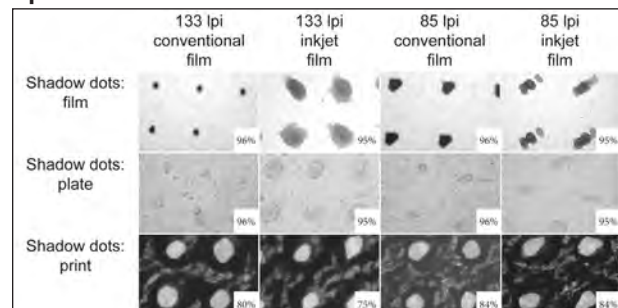


Figure 3

The limitations of the inkjet film showed most notably in the highlight areas (Figure 4). For highlight dots, edge artifacts were clearly present under magnification in the inkjet-produced film. In Figure 4, note the gray fringe surrounding the clear dots of the inkjet film. The smallest highlight dot that our tests reproduced on inkjet film was an 8% for the 133 lpi screen and a 5% with the 85 lpi

screen. Any dot smaller apparently filled in too much for light to adequately pass through the film to expose the plate material. Conversely with the imageset film, 2% dots were easily held in highlight areas for both the 85 lpi and 133 lpi screens. A small amount of dot gain resulted in the highlight, with dots growing about 2% to 4% on press.

A comparison of highlight dot reproduction for film, plate and print.

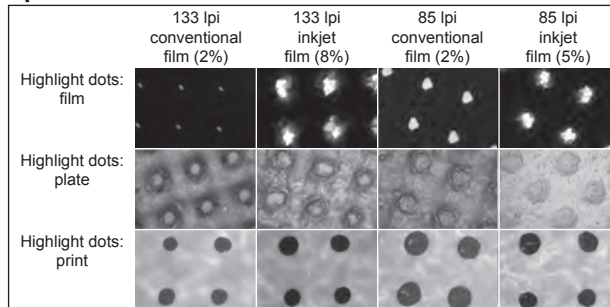


Figure 4

Film Handling and Material Costs

The brand and quality of film base used is very important. We tested two different film bases and found that the “non-waterproof” film (refers to specific coating applied to a film to better adhere inks, one of the factors in determining which to use is if pigments or dyes are used) had drying problems and the ink did not adhere well or form solid dots well. When exposing plates under contact pressure, the ink on the film adhered to the plate during removal. It also became soluble when brought into contact with water causing the ink film to bleed. The “waterproof” film yielded much higher quality results. The ink adhered well, and the ink dried faster and more completely, with no ink transfer to plates during plate exposure. Regardless of film used, handling with care is important. The inkjet films can be scratched easier than silver-halide film emulsions. The inkjet ink is water-soluble, so water will dissolve the image areas; especially on the “non-waterproof” film.

Our cost analysis, done in September of 2010, found that the cost per square foot for silver-based film is \$1.95. This price includes the cost of the film, developer, fixer, & necessary replenisher. The cost of two chemical changes per roll were also taken into account. The cost per square foot for inkjet film is \$2.04. This included the cost of the film base material plus a 220ml Photo Black cartridge projected to image 101 square feet. The cost of the film base material was \$177 for 142 square feet. The time required to image the film is similar for both inkjet gener-

ated and imagesetter-generated film, so the cost in labor is equal.

Conclusions

In this research, the inkjet-generated films perform well for imaging photopolymer flexographic plates. It appears that inkjet film might be suitable for flexographic markets where coarser screen frequencies (in the 55–133 lpi range) are the norm, such as for some wide web applications and for corrugated board. With our testing, the highlight dots and shadow dots did not reproduce as well with inkjet film as they did with conventional film. While this can be compensated for in prepress by targeting proper dot values, there may be more tonal compression (from the original image to the final print) when using inkjet generated film. Text and fine lines were adequately reproduced by inkjet film, but finer lines were reproduced with imageset film. Further research is planned for examining various dot shapes and resulting multicolor printing rosette patterns. Preliminary testing shows that the rosettes reproduced well, but more research is needed to report on these findings.

It is important to note that the results on press will be extremely variable for different applications and in different facilities. For Flexography, the print reproduction will depend upon the anilox roll (cell type, cell count, and physical condition), the type of substrate (film, foil, label, paper), ink characteristics (solvent/water, viscosity, pH), and the type of ink metering system used (two-roll, two-roll modified, or enclosed chamber) (FFTA, 1999). We did achieve decent results on press in our testing, but each individual facility will have its own variations.

There are notable advantages to inkjet film. The overall footprint for equipment can be decreased by eliminating an imagesetter and processor, as an inkjet device can be multi-purposed for both proofing and film production. Depending upon state and local laws, disposal of the chemicals necessary for conventional film production may be adding to the bottom line and a facility may find cost benefits here. Inkjet technology for film production uses aqueous-based inks that have a minimal environmental impact, and little waste. The cartridges in which the ink is purchased can be refilled or recycled to further deter environmental impact. The overall material cost difference between inkjet film and imagesetting film is negligible.

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Women vs. Men: How Gender Impacts Employment in the Graphic Communication Industry

by Twyla J. Cummings, Ph.D. • Patricia Sorce, Ph.D. • Ashley Walker, M.B.A. • Rochester Institute of Technology

Once predominately male oriented, printing is now an industry that employs women in many key positions. As Baby Boomers retire, the industry has as many as 5,000 jobs to fill annually and is challenged with finding enough qualified young people to apply. Baccalaureate programs in printing and graphic communication are also finding it difficult to attract applicants to their programs (Sorce and Walker, 2009). It is critical that companies and academic institutions target the female demographic as a viable resource to fill these types of positions. Will women find employment in printing and other graphic communication firms appealing? In order for firms to find the skilled workforce needed to address the changes in the industry, they will need to demonstrate that women have similar opportunities for successful careers as men.

Women in the Printing Industry

Women have been an integral part of the printing industry for centuries. Traditionally, prominent positions for women became available to women due to the death of a spouse or through the inheritance of the family business. The first female printer of note was Charlotte Guillard, who took over her husband's printing business following his death in 1540 (Printing Manager, 2004). In 1767 Anne Catherine Hoof Green became the owner of her late husband's printing press and ran the company until her death in 1775 (Raha, 2007). Today women can be found in varying roles within printing companies and in other areas throughout the graphic communication industry. Women such as Joan Davidson, Group President of Sheridan Publication Services, who says when she came into the graphic communication industry she faced a male-dominated culture as opposed to what she experienced in her previous career at Proctor and Gamble. Laura Gale, Vice President Marketing for United Stationers, says that her entry and career growth in the printing industry was the result of a caring mentor who encouraged her to seek an opportunity in production which would later establish her career in graphic communication technology (Printing Manager, 2004).

Even with these success stories the questions that remain include how are women faring in the printing, publishing and graphic communication industry and are there simi-

lar opportunities for career advancement when compared to men? As a starting point, we will use a study conducted in 2000. The key findings of that study were:

1. The majority of women in the graphic communication industry were employed by manufacturers/suppliers.
2. The majority of the survey respondents worked in sales and marketing.
3. Many women transitioned from other areas into the graphic communication industry.
4. Gender pay inequity was noted as the major problem/challenge that women encountered (Cummings, 2004).

While the 2000 study produced some interesting findings, it was limited in that it focused only on women so no statistical comparisons were made with men in similar positions. The purpose of the present research study was to get a snapshot of employment status of both men and women graduates from one major printing program. The sample has the added advantage of comparing employees who had a similar educational experience, which is one factor that can lead to differences in employment success. The sample is drawn from the 2008 RIT Printing Industry Center study that assessed the correlates of job satisfaction of early career employees in printing and publishing occupations. The goal of the 2008 research was to determine which factors correlate to overall job satisfaction. The current research assesses the same sample from this study to compare the employment patterns of males and females. The research objective of this study was to determine where women and men are positioned in the printing industry in terms of firm demographics, salary, and job title.

Methodology

The ex post facto method was used to conduct an experimental research design to determine if there were any significant differences based on gender. The dependent variables were job titles, company type, number of employees in company, and salary. Lastly, a comparison of gender on a number of job satisfaction factors was also examined.

Research Sample

The 2008 Printing Industry Center study surveyed 1,845 School of Print Media (SPM) alumni. From this survey there were a total of 442 responses of which 318 were from males (71.9%) and 124 (28.1%) were from females. The survey, which was administered using an online survey service, was designed to collect the following kinds of information: demographic information, information on the job and company where the respondent was employed, and level of job satisfaction.

Results

Approximately 18% of the male respondents were between the ages of 20–29 compared to 51.2% of the females. A chi-square analysis revealed a significant difference in age by gender, chi-square (1,9) = 70.3, $p=0.0001$. None of the female respondents were over the age of 55; however 24.6% of the male respondents were in this age range. The majority of the males were in the 30–54 age range.

Because age was confounded with gender, the remaining analyses were conducted on those respondents who were under the age of 45. Table 1 shows this breakdown. Even though there still is a significant age difference between the males and females from this sample population, it is greatly reduced as compared to the total population of respondents, chi-square (1,4) = 17.12, $p=0.002$.

Age Range	Male % Response n=145	Female % Response n=102
20–24	10.3	21.6
25–29	26.2	40.2
30–34	24.8	10.8
35–39	18.6	12.7
40–44	20.0	14.7
Total %	100.0	100.0

Type of Firm Where They Work

Table 2 shows that 26.9% of the female respondents work for commercial printing firms as compared to 29.7% of the male respondents. Only 8.6% of the male respondents reported working for a publishing firm while 7.5% of the female respondents reported employment in this area. Overall there was not a significant difference between

Table 2: Type of Firm Where Employed

Type of Firm	Male % Response n=128	Female % Response n=93
Commercial printing	29.7	26.9
Publishing	8.6	7.5
Advertising	1.6	7.5
Design/prepress firm	0.8	2.2
In-house corporate communications/ marketing department	6.3	4.3
In-house educational/non-profit communications/marketing department	0.0	1.1
In-House Education Non-Profit/ Corporate Print Shop	3.1	5.4
Other	50.0	45.2
Total %	100.0	100.0

men and women in the type of firm where they were employed, chi-square (1,8) = 8.58, $p=0.378$.

Size of Firm

The gender difference in size of firm where they were employed was not significant, chi-square (1,4) = 1.173, $p=0.883$. Table 3 shows that approximately 25% of both males and females work for firms under 50 employees. Similarly, approximately 37% of males from this group worked for firms with more than 500 employees and as compared to 40% of the female respondents.

Number of Employees at Company	Male % Response n=125	Female % Response n=87
Less than 50	26.4	23.0
51–100	12.0	9.2
101–200	12.8	16.1
201–500	12.0	11.5
>500	36.8	40.2
Total %	100.0	100.0

Job Title

Respondents were asked about their current job titles/ areas. As this was an open-ended item, many unique titles were generated. Two titles, sales (and marketing) and management were selected for discussion. Approximately

11% of the male respondents indicated that they worked in the area of sales and marketing versus 13% of the female respondents. Similarly, the plurality of the female (34.2%) and male (39.0%) respondents reported being in a management role with their current employers and/or were the business owners.

Annual Income

Because age and salary were highly correlated even in the sample that was under age 45, a 3-way chi-square analysis with age, gender and salary was conducted. To simplify the analysis, age was recoded into three categories (under 30, 30–39 and 40–44) and salary into three categories (under \$40,000, \$40,000–\$60,000, and over \$60,000). Table 4 shows the results. For males, as age increased so did salary and this relationship was statistically significant, chi-square (1,4) = 17.9, p=0.001. Just under half of the men (46%) in their 20's earned over \$60,000 while 92% of the men in their early 40's did.

	Annual Income	<29 years of age	30–39 years of age	40–44 years of age
Male		n=44	n=58	n=26
	Under 40K	13.6%	5.2%	3.8%
	40–60K	40.9%	22.4%	3.8%
	Over 60K	45.5%	72.4%	92.3%
Total		100.0	100.0	100.0
Female		n=59	n=20	n=13
	Under 40K	28.8%	20.0%	30.8%
	40–60K	47.5%	50.0%	23.1%
	Over 60K	23.7%	30.0%	46.2%
Total		100.0	100.0	100.0

For females, though the trend was in the same direction, age was *not* significantly related to income, chi-square (1,4) = 4.01, p=0.40. Whereas only 24% of female respondents in their 20's earned \$60,000 or more, only 46.2% of those in their early 40's reported the same. Moreover, the gender differences also appeared in the youngest age group. Only 14% of the men in their 20's earn less than \$40,000; the percentage for women was double at 29%.

Level of Job Satisfaction

The study respondents were surveyed on 23 job satisfaction facets. Of the 23 facets only “level of challenge” [F(1,195) = 9.93 and p=0.002] and “salary” [F(1,195) = 4.48 and p=0.036] showed significant differences with

gender. The facets were assessed on a 5-point scale where 1 = very satisfied and 5=very dissatisfied. Female respondents were less satisfied with level of challenge (mean = 2.38) than the male respondents (mean =1.95). Additionally, the female respondents were less satisfied with salary (mean =2.86) as compared to the male respondents (mean =2.58).

Discussion

The data revealed that there are no significant differences between the male and female study respondents in terms of job title and company type. However salary showed a significant difference between genders. While women and men in this study who are employed in printing and other graphic communication industry sectors are working for the same types of companies and have similar jobs, men were paid significantly more across all age ranges. There are a myriad of reasons for this disparity; one likely reason is that men have been in the professional workforce longer and have greater seniority. While we did not examine seniority per se, the additional analysis revealed that a smaller percentage of women from each age group were at the upper income scales than were men. Explanations for the difference in salary could be that 1) there is still gender bias; 2) women don't advocate well for themselves; or 3) women are taking time out for family which traditionally stalls career advancement. While the authors cannot determine which among these is the primary cause of the difference in salary, we can elaborate on one factor that educators can address. If women are not experienced in negotiating higher starting salaries and thus begin their careers at a lower pay scale than their male counterparts, we can include negotiating skills into the career preparation courses that many of our universities offer to all students. We owe it to our female students to teach them to learn to value themselves appropriately when they engage in their job searches, even in this recessionary climate of the last few years.

In sum, women represent a significant percentage of the professional workforce. With workforce shortages in the graphic communication industry and with fewer students pursuing graphic communication related degrees, there will be fewer people in the pipeline to fill these shortages. Graphic communication industries unfortunately are not immune from fact that women earn only 77cents for every dollar of a man's salary (Bialik, 2010). The outcome of this research study should highlight the importance of equitable recruiting, development and retention of female employees.

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The Curricular Importance of Six Sigma as Rated by Printing Professionals in Indiana

by Edward J. Lazaros, Ph.D. • Thomas H. Spotts, Ph.D. • Ball State University

Introduction

Six Sigma, known as a quality initiative at Motorola in the 1980s, a cost reduction initiative at General Electric in the 1990s, and a strategic management initiative focused on value at DuPont in the 2000s, has expanded beyond manufacturing to other sectors. The printing and visual communications industry, like other manufacturing and service industries, appears to be embracing Six Sigma principles. This quality initiative may be appropriate to integrate into undergraduate printing management degree programs to give students exposure to concepts that they may encounter when graduating and joining the workforce.

As a quality improvement initiative, Six Sigma focuses on the customer; as a cost reduction initiative, the focus is on the provider and company stakeholders. Six Sigma is both a quality improvement program and a cost reduction program; however, it is also a strategic management strategy focused on value for both the customer and the provider. In improving quality, reducing defects, and lowering costs, Six Sigma is focused on helping companies deliver goods and services at the highest value obtainable (Harry and Crawford, 2004). These are principles that may be important for undergraduate printing management students to study to better prepare them to enter the workforce.

The printing industry is historically considered the third or fourth largest manufacturing industry in the world (Kleper, 2002). According to Davis (2010), in the U.S. in 2008 the total shipments were \$166.6 billion, employment was 976,400, and there were 36,508 establishments. Due to economic conditions in 2009, the number of printing plants declined to 33,565. The total shipments were \$140.7 billion and employment was 909,200.

The printing industry, like other manufacturing and service industries, appears to have embraced these Six Sigma principles. This is evidenced by the variety of workshops sponsored by industry organizations promoting Six Sigma. The workshops advertise sessions that will turn a company around, increase company profit, deliver measurable results, and keep attendees returning to the conference year after year. Industry magazines frequently feature articles or entire issues that focus on Six Sigma. (Gentile, 2007). As this is something that the printing

industry strives to embrace, an introduction to Six Sigma principles in printing management programs may benefit both the student and the industry.

Though it appears the printing industry has made significant moves toward embracing Six Sigma (reflected by conferences, workshops, and publications), it is usually the large companies that adopt Six Sigma initially and profit from the methods. The traditional approach of hiring a consultant or training management personnel as Six Sigma professionals may be cost prohibitive for many small to medium companies in the printing industry. Small and medium firms do not have the financial resources to hire consultants or train their managers to be Six Sigma professionals; however, they may hire recent college graduates with a Six Sigma background and benefit from their knowledge. Therefore, there may be a potential market for a printing management degree with a minor emphasizing Six Sigma business strategies.

The Illinois/Indiana region of the Midwest accounts for 8.8% of these U.S. printing plants, employing 10% of the print employment and producing 10% of total dollar value of the U.S. printing shipments (Davis, 2007). To gain insight into whether the printing industry in the Midwest offers a market for a printing management program degree with a minor that emphasizes Six Sigma strategies, a survey of the Printing Industry of Illinois / Indiana (PII) members was conducted to determine the importance of and interest in Six Sigma principles. This information could have implications for further research on adding Six Sigma coursework as part of undergraduate programs nationwide.

Literature Review

In 1981, Motorola's CEO, Robert Galvin, challenged the company to achieve a tenfold improvement in performance over a five year period (ASTD, 2000). This was a period where American manufacturers were producing lower quality products compared to the high quality products being produced by Japanese companies. Poor quality was seen as a threat to future success and much of the work toward improving performance was directed toward "quality" in the form of defect reduction.

The focus on quality at Motorola resulted in the company winning the first newly established national quality award

(Baldrige, 1988). The award brought satisfaction and notoriety to Motorola but it also created a problem. Since companies were not able to compete for the award again for five years, the award could not serve as a driving force for continued improvement (Harry, 2000).

Most of the Six Sigma literature reviewed focuses on larger companies/industries. With this in mind, a survey was conducted of Printing Industries of Illinois/Indiana (PII) Indiana member companies, representing a broad base of small to large printing companies, to determine if there is interest in these principles among Midwest Printers. Familiarity and interest in Six Sigma principles might indicate a potential market for a Graphic Arts Management Degree that offers a minor focusing on the Six Sigma principles.

Statement of the Problem

There is a lack of information pertaining to the rated importance of newly hired employees in the field of printing having knowledge of the Six Sigma principles. Also, it was not known whether the demographic variables including number of employees, primary business, and annual operating budget affected the rated importance of the Six Sigma principles for newly hired employees.

Purpose of the Study

The purpose of this study was to identify the importance of incoming employees having knowledge of commonly recognized principles associated with Six Sigma. Employers were asked to explain which of the six items on a survey were most important to their business and why. Since many of the associations' members may be unfamiliar with Six Sigma principles, these principles were clearly defined on a survey instrument. The results from the survey may suggest a market for a Six Sigma minor coupled with a management degree in printing management to better prepare graduates with the knowledge and skills deemed important by employers. This was of interest to the researchers of this study because they were considering the feasibility of offering a Six Sigma minor as an option within a baccalaureate of science degree in Graphic Arts Management.

Significance of the Problem

To develop strategies to implement Six Sigma training in printing preparation programs at the university level, it would be helpful for the profession to know the level of importance attribute to these principles for newly hired employees in the printing field. Also, insight into

whether there is any difference in rating based upon company demographics has implications for determining if Six Sigma training should be implemented at the university level.

Research Questions

This study was designed to answer the following questions:

1. For newly hired employees what level of importance is placed on knowledge of each of these Six Sigma areas (as rated by PII association's Indiana members):
 - (a) focus on the customer
 - (b) data and fact driven management or metrics for decision making
 - (c) strategic driven process improvement
 - (d) continuous improvement
 - (e) boundless collaboration
 - (f) drive for perfection.
2. Were there differences based on company demographics (including number of employees, primary business, and annual operating budget) and ratings on the need for for newly hired employees to have knowledge of Six Sigma principles?

Assumptions

This study assumed that the PII association's Indiana members were in the best position to reflect on their company and rate the importance of knowledge of Six Sigma principles for newly hired employees.

Limitations

This study was conducted under the following limitations:

1. The results obtained by the use of the survey are only as valid as the respondent was conscientious in completing the survey.
2. This study was confined to 102 PII association's Indiana members and may not be easily generalized to printing companies in other areas of the country.
3. Because multiple statistical tests were run, there was a strong possibility that type one errors may have occurred.

Methodology and Design

Passive descriptive survey and sampling was used as a quantitative approach in this study. The sample for the study consisted of 102 of Indiana members of the PII. This study was conducted in the state of Indiana. The

researcher's familiarity with the printing companies in Indiana and availability of a PII association database was a factor in choosing this sample.

A survey was sent on November 1st, 2007. Two weeks after the first mailing, 29 printing companies had returned the survey. This represented a 28% return rate of the survey. A second mailing of the survey packet yielded a total of 36% percent return rate of the survey.

The instrument consisted of two sections. The first section of the survey was demographic data. The second section of the survey was a four-point Likert-type scale to measure responses pertaining to the importance of principles associated with Six Sigma. The four-point Likert scale values were as follows: 1 = No Importance, 2 = Little Importance, 3 = Moderate Importance, and 4 = High Importance. The items on the survey instrument were as follows:

1. Focus on the customer. *The ability to gather, analyze, and incorporate customer input into the organization's business goals.*
2. Data and fact driven management or metrics for decision making. *The ability to make decisions by measuring, analyzing, and controlling key metrics at all levels of the organization.*
3. Strategic driven process improvement. *The ability to convert strategic objectives into process improvement projects which will in turn impact the strategic objectives in a positive way.*
4. Continuous Improvement. *The ability to understand and to constantly evaluate the status quo for opportunities of improvement.*
5. Boundless collaboration. *The ability to breakdown corporate barriers through the deployment of teamwork and other interpersonal skills and techniques.*
6. Drive for perfection. *The ability to apply statistical techniques, process mapping, and other technical skills in the elimination of defects.*

For statistical analysis, the categorical variable was the level of respondents' demographic characteristics (number of employees, primary business of the organization, annual operating budget of the printing facility). The dependent variables were the respondents' mean scores on each survey item (focus on the customer, data and fact driven management or metrics for decision making, strategic driven process improvement, continuous improvement, boundless collaboration, and drive for perfection).

Demographic Data

The PII association's Indiana members were asked to identify the number of employees (See Table 1), primary business (See Table 2), and annual operating budget (See Table 3) for their business. Demographic data were recorded using frequencies.

Table 1: Primary Business

Primary business	Respondents
Affiliated services	1
Binding/finishing	2
Book publishing	2
Book printing	1
Book, commercial, binding/finishing	1
Business forms	2
Consultant group/affiliated services	1
Envelope manufacturing	1
Newspapers, commercial	2
Printing equipment sales	1
Quick printing	1
In-plant	1
Commercial printing	16
Commercial binding/finishing	1
Commercial binding/finishing, packaging	2
Commercial business forms, binding/finishing	1
Commercial quick printing	2

Table 2: Annual Operating Budget

Annual operating budget	Respondents
Under \$1 million	11
\$1-3 million	9
Over \$3 million	16

Table 3: Number of Employees

Employees	Respondents
1-5	1
6-10	8
11-20	8
21-30	6
21-50	1
51-100	9
100+	5

Research Question One

Research question one was analyzed by using descriptive statistics (See Table 4). The highest rated Six Sigma principle was focus on the customer ($M = 3.76$, $SD = 0.64$) by the PII Association's Indiana members. This was followed by continuous improvement ($M = 3.65$, $SD = 0.53$) and boundless collaboration ($M = 3.41$, $SD = 0.72$). The data indicated that the respondents noted these principles as "moderate to high importance". Survey participants provided open ended responses justifying their rating of the Six Sigma principles on the survey instrument. These responses yielded some insight into why "focus on the customer" was the highest rated principle. Participants noted "meeting and exceeding customer expectations is paramount", "customer must be the focus", "focus on the customer-internal or external- if we have this focus we are better positioned to address/implement all the others-it starts with the customer, and "customer focus sets the tone for all actions / attitudes". The participant responses also yielded some insight into why "continuous improvement" was the second highest rated principle. Participants noted "we are constantly evaluating new procedures and technologies to remain competitive", "without this there is no motivation, desire to improve", "data and fact driven which allows us to save our customers money", "continue to improve methods of delivering education along with improving recruiting effectiveness", and "applying statistical data to work flow processes improves through out and over all performance". Regarding "boundless collaboration", the participant responses yielded insight into why this was rated as the third most important Six Sigma principle. Participants noted "we strive to be a team at all times", and "I have the customer involved. I can make the changes in our organization so I am always ready to supply my customer's needs".

Table 4: Six Sigma Principle

	N	Mean	Rank	SD
S1. Focus on the customer	37	3.76	1	.641
S2. Data and fact driven management or metrics for decision making	37	3.24	5	.683
S3. Strategic driven process management	37	3.19	6	.739
S4. Continuous improvement	37	3.65	2	.538
S5. Boundless collaboration	37	3.41	3	.725
S6. Drive for perfection	37	3.38	4	.721

Research Question Two

Research question two was analyzed by performing a multivariate analysis with the six questions as dependent variables and the rating as the independent variable. The Pillai's Trace test resulted in a p-value of 0.000 indicating there is a difference in rating means among the six survey questions. Mauchly's test of sphericity resulted in a p-value of 0.014 indicating at least one of the covariances of the question ratings was different. Based upon the results of Mauchly's test, the univariate Huynh-Feldt test was performed resulting in a p-value of 0.000 confirming the result of the Pillai's Trace test. Pairwise comparison was performed with the results summarized in Table 5 indicating two groups: Q1-Q4 and Q2-Q3-Q5-Q6.

Mean ratings of importance with 95% confidence upper and lower bounds are graphed in Table 6. The respondents indicated that all of the Six Sigma principles were at least moderately important (mean rating > 3.0 for all questions), but indicated that "focus on the customer" and "continuous improvement" were more important than "data and fact driven management or metrics for decision making," "strategic driven process improvement," "boundless collaboration," and "for perfection." The average rating was 3.437.

The survey demographics identified three groups based upon annual operating budget: 1) Under \$1 million; 2) \$1-3 million; and 3) Over \$3 million (See Table 7). The Pillai's Trace test resulted in a p-value of 0.760 for Budget as a between subject factor, indicating no significant difference in response based upon annual operating budget. Mauchly's test of sphericity resulted in a p-value of 0.045 indicating at least one of the covariances of the question ratings was different. Based upon the results of Mauchly's test, the univariate Huynh-Feldt test was performed resulting in a p-value of 0.672 confirming the result of the Pillai's Trace test. The mean ratings of importance appear in Table 8.

While statistically, there is no significant difference by respondents based upon annual budget, the following anecdotal observation may be observed: On average, small and moderate-sized company ratings were much lower for question 2 *data and fact driven management or metrics for decision making* and question 3 - *strategic driven process improvement*, when compared to other questions. One explanation might be that it is very common for smaller and moderate-sized companies to rely more heavily on intuitive management and short term tactical planning than large companies.

The survey demographics identified seven groups based upon number of employees. For analysis purposes the seven employee groups were reduced to two as indicated in the Table 9. The Pillai's Trace test resulted in a p-value of 0.466 as a between subject factor, indicating no significant difference in response based classification by number of employees. Mauchly's test of sphericity resulted in a p-value of 0.043 indicating at least one of the covariances

Table 5: Questions and Comparisons

Question	Comparison question	P-value (indicates difference)	
1	2	0.000	
	3	0.000	
	4	0.291	
	5	0.003	
	6	0.003	
	2	1	0.000
2	3	0.534	
	4	0.000	
	5	0.160	
	6	0.281	
	3	1	0.000
	2	0.534	
3	4	0.000	
	5	0.103	
	6	0.198	
	4	1	0.291
	2	0.000	
	3	0.000	
4	5	0.010	
	6	0.023	
	5	0.003	
	2	0.160	
	3	0.103	
	4	0.010	
5	6	0.822	
	6	0.003	
	2	0.281	
	3	0.198	
	4	0.023	
	5	0.822	

Table 6: Mean Ratings of Importance

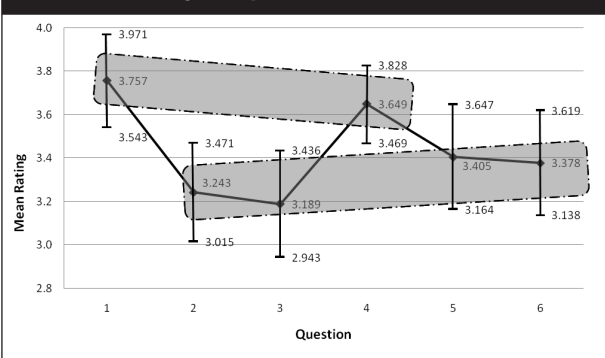


Table 7: Respondents by Annual Operating Budget

Size of company	Number of respondents
Under \$1 million	11
\$1–3 million	9
Over \$3 million	16

Table 8: Rating by Annual Operating Budget

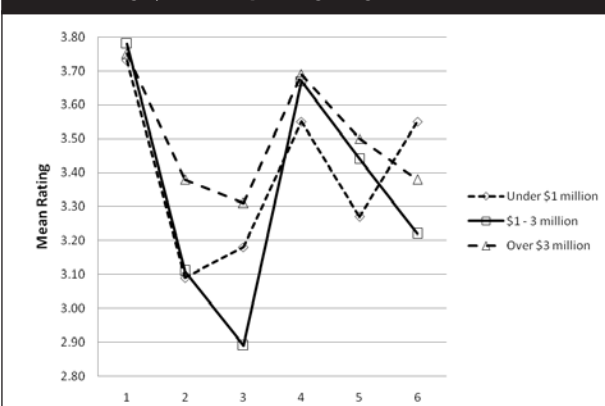
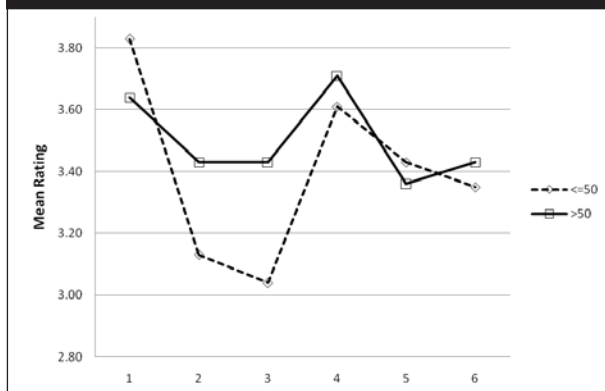


Table 9: Survey and Analysis Groups

Survey groups		Analysis groups	
Employees	Respondents	Employees	Respondents
1–5	1	<=50	24
6–10	8		
11–20	8		
21–30	6		
21–50	1		
51–100	9	>50	14
100+	5		

of the question ratings were different. Based upon the results of Mauchly's test, the univariate Huynh-Feldt test was performed resulting in a p-value of 0.149 confirming the result of the Pillai's Trace test. The mean ratings of importance appear in Table 10.

Table 10: Rating by Number of Employees



Both annual operating budget and number of employees are indicative of company size. Since analysis based upon both classifications was insignificant, it can be concluded that there is no difference in the response based upon company size. The anecdotal observation identified for the annual operating budget variable can also be observed in the analysis by number of employees.

The survey demographics identified eighteen groups based upon primary business classification. For analysis purposes the seven employee groups were reduced to two, as indicated in Table 11.

The Pillai's Trace test resulted in a p-value of 0.927 for classification by commercial versus non-commercial as a between subject factor, indicating no significant difference in response based primary business classification. Mauchly's test of sphericity resulted in a p-value of 0.019 indicating at least one of the covariances of the question ratings was different. Based upon the results of Mauchly's test, the univariate Huynh-Feldt test was performed resulting in a p-value of 0.886 confirming the result of the Pillai's Trace test. A graph of the mean ratings of importance is shown in Table 12. There is statistically no difference in respondents rating based upon primary business.

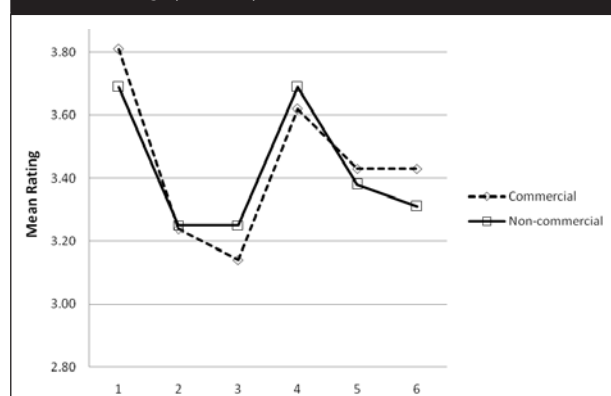
Conclusions and Recommendations

1. It is recommended that the Six Sigma related principles of "focus on the customer", "continuous improvement", and "boundless collaborations" be areas of primary focus during an undergraduate

Table 11: Survey and Analysis Groups

Survey groups		Analysis groups	
Primary Business	Respondents	Employees	Respondents
Affiliated services	1	Non-commercial	16
Binding/finishing	2		
Book publishing	2		
Book printing	1		
Book, commercial, binding/finishing	1		
Business forms	2		
Consultant group/affiliated services	1		
Envelope manufacturing	1		
Newspapers, commercial	2		
Printing equipment sales	1		
Quick printing	1		
In-plant	1		
Commercial printing	16		
Commercial binding/finishing	1		
Commercial binding/finishing, packaging	2		
Commercial business forms, binding/finishing	1		
Commercial quick printing	2		

Table 12: Rating by Primary Business



experience since they were rated highly with regard to importance to businesses as part of this small study. The data from this study indicated, “focus on the customer” was the highest rated Six Sigma concept, followed by “continuous improvement”, and “boundless collaboration”. These findings could have useful implications for academic programs considering introducing Six Sigma content as part of an undergraduate experience. It is recommended that future research be conducted with a larger sample, and such a study should investigate why the ranked Six Sigma principles were perceived as more important than the other principles. A future study could also use focus groups, which might be a more effective option for this particular study and offer greater insight into the desirability of Six Sigma trained graduates for the printing industry.

2. When comparing the perceived importance of Six Sigma principles to the demographic variables of primary business, company size, and operating budget, there were no statistically significant differences. One possible conclusion may be that the Six Sigma principles are of value regardless of the primary business, company size, or operating budget. It should be noted that all of the Six Sigma principles were at least moderately important (Mean Rating > 3.0) as indicated by the respondents. This would seem to indicate value placed on these principles by the sample of individuals in the printing industry, and it may justify incorporating Six Sigma preparation as part of an undergraduate program. Certainly, the results of this study are not to be generalized to the larger population because of the small sample size. As previously noted, future research should investigate the level of importance of the Six Sigma principles for newly hired employees as rated by a larger sample of individuals in the printing industry.

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The Relationship between Size and Performance of Commercial Printing Companies

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Introduction

Web technology is fast growing. It has multi-functional tools that has a number of benefits for companies. Companies can use Web technology as a business tool to publish information about their products and services, to market and sell their products and services, and to communicate with their customers, vendors, and employees. Additionally, companies can offer technical support and receive payments through Web technology. Findings gathered from the review of literature showed that there were contradictions on the effect of Web technology on the performance of companies. Some professionals believed that their companies were performing better because of Web technology. Some professionals did not notice any change in the company's performance. On the other hand, some professionals perceived that Web technology adversely affected their performance.

Based on the review of literature, an empirical research study was conducted to investigate the relationship between the size of commercial printing companies and performance for conducting business-to-customer (B2C) operations or e-commerce on the Web. The performance was divided into three categories: financial, non-financial, and overall. The financial performance (FP) was measured using four financial indicators: sales, profits, costs, and return-on-investment (ROI). The indicators used for measuring the non-financial performance (NFP) were number of customers, merchandise return rate, and sales and marketing productivity. The overall performance (OP) was measured by combining both financial and non-financial indicators.

Study Rationale

This research was conducted to investigate the relationship between the size of a commercial printing firm and its financial and non-financial performance when conducting B2C operations using Web technology.

Not many commercial printing firms were performing well on conducting B2C operations over the Web. Roth (1998) cited that printing companies had not benefited by creating web sites for conducting business over the Web. The presence of web sites did not boost their profits. On the other hand, Auger (1997) found multi objective web site, advertisement of a web site, and number of visitors

positively affected the overall performance of a company in computer, telecommunications, electronics, and food industries. It was not found from the review of literature whether the size of a commercial printing company has any effect on performance. However, Rogers (1994) stated that large organizations are early adopters of technology and gain profits. As a result, the research was performed to determine whether the large commercial printing firms are performing better than medium-sized and small-sized commercial printing firms from conducting B2C operations over the Web.

Hypotheses

Based on a review of literature, the following hypotheses were formulated:

- H₁: There is a positive association between the size of a commercial printing firm (as measured by the number of employees) and its financial performance in conducting B2C activities on the Web.
- H₂: There is a positive association between the size of a commercial printing firm (as measured by the number of employees) and its non-financial performance in conducting B2C activities on the Web.
- H₃: There is a positive association between the size of a commercial printing firm (as measured by the number of employees) and its overall performance in conducting B2C activities on the Web.

Review of Literature

This paper is mainly based on Rogers' theories from within the book *Diffusion of Innovations* (1995); Auger's empirical study from his dissertation titled *Marketing on the World Wide Web: An empirical investigation of the relationship between strategy and the performance of corporate Web sites* (1997); and Roth's findings from her article *Printers and the Internet* (1998). Rogers (1995) defined diffusion as "the process by which an innovation is communicated through certain channels over time among the members of a social system" (p. 5). The innovation can be an idea, practice, or object that is perceived as new by an individual or other unit of adoption (Rogers, 1995). This study examines the Web as an innovation or technology and its diffusion in society in terms of how it

brings changes to the organizational performance of companies. Rogers (1995) stated that the consequences are the changes that occur to an individual or to a social system as a result of the adoption or rejection of an innovation.

There are adequate findings on desirable, direct, and anticipated consequences of Web technology based on the Rogers' theory. McLean (2000) said that Web sites could be powerful tools for printers, if they were well constructed. He added that Tonya Starr, president of Premierprinter.com, cited the research study finding that a company that has a Web site achieves a 35% higher level of credibility than a company that does not. Behrens (1997) indicated that the usefulness of e-mail and Web sites as present-day marketing vectors can trigger sales promotion, and thus can be widely used by many printing companies. Williamson (1997) stated that using the appropriate software, Internet-based retailers can communicate customized messages and promotions to individuals with the desired interests and shopping patterns. Because of interactive technology, manufacturers can build a one-to-one relationship with their customers, tailoring the marketing mix to individual preferences (Pine, Peppers, & Rogers, 1995). Hirshowitz (1997) stated that the World Wide Web provides several benefits to quick printers. For instance, Kinko's uses its site to display products and services, while Herndon, a Virginia-based Insty-Print, generates \$5,000 to \$15,000 monthly sales on the Internet (Hirshowitz, 1997). Hirshowitz (1997) cited that AlphaGraphics in Scottsdale, Arizona, developed a Web site that allows customers to transact business with its 300 franchised print shops worldwide. In 2000, Frank Romano, then chair of the School of Printing, Rochester Institute of Technology, mentioned that e-commerce would allow printers to deal more efficiently with the everyday rapid changes ("E-commerce options," 2000). Cummings and LeMaire (2006) found from their empirical study that printers, customers, and end users all benefited from e-commerce services in the printing industry. Based on Rogers' theory, there are undesirable, indirect, and unanticipated consequences associated with Web technology, also. It was stated in the "The Ultimate E-commerce Study" (2002) that the Indian industry has clearly understood that e-commerce is not a solution for all business problems and marketing strategies. It is important to note that a blind choice of Web technology has further added to many firms' problems, those who have been unable to comprehend the effect of the Web on their businesses. Durfee and Chen (2002) indicated that

one of the important lessons learned in the early 2000s is that e-commerce is not for everyone, because investments are significant, and mistakes are expensive and highly visible. Roth (1998) cited the findings of research conducted by the Graphic Arts Marketing Information Service of Printing Industries of America (GAMIS/PIA) that not many printing companies are making profits by conducting business-to-customer activities on the World Wide Web. Roth indicated that only 11% made money on Web sites, while 43% thought they broke even and 38% lost money. Burke (1997) discovered that existing retailers have also been reluctant to support electronic shopping for the following reasons:

1. Building and maintaining a Web site requires a significant investment of time and money with an uncertain return on investment.
2. If retailers post their prices on the Internet, customers and competitors have easy access to this information, increasing market efficiency and reducing margins.
3. Electronic-sales incur shipping and handling costs.
4. Electronic-sales have higher return rates of goods because sometimes customers do not obtain the goods that meet their expectations.

In another study, Jarvenpaa and Todd (1997) indicated that the main drawbacks of Internet shopping were not technical issues like network security and bandwidth. Instead, consumers complained that the Web was hard to navigate, specific items were difficult to find, and offerings of individual sites were too limited and not competitive in price. Auger (1997) conducted similar research to investigate the relationship between a Web strategy and the financial and non-financial measures of performance of a company. He concluded that there was a positive association between multi-objective sites and overall performance. Additionally, he found a positive relationship between advertising of the Web site and overall performance. Auger investigated that there was a similar relationship between the number of visitors and overall performance as well as between the frequency of site updates and overall performance. Surprisingly, he found a negative association of Web site design features and services with overall performance. Further, Auger found that the more complicated the Web site, the less the number of visitors. Hence, the overall performance could be negatively affected.

Nath, Akmanligil, Hjelm, Sakaguchi, and Schultz (1998) conducted research on e-commerce. They interviewed

executives of ten organizations. They found that the executives believed that the Internet was an inexpensive advertising tool that can reach a huge audience, the barriers to conducting business were minimal, and an Internet presence improved the image of the business. However, they also found that executives were worried about security, costs, site maintenance and support, lack of knowledge, lack of skilled personnel, and legal issues.

Rogers (1995) indicated that the size of a company and the early of adoption of technology are positively related to organizational profits. This is based on Rogers' idea that large organizations are early adopters and, by being first in the field, they gain windfall profits. Relevant and supporting evidences for this idea were found in other studies. Acs and Audretsch (1990) found that the rate of innovation varies from industry to industry for both large and small firms. In 1982, the large-firm innovation rate (LIE) was the highest for rubber manufacturers (2.1814); whereas, the small-firm innovation rate (SIE) was the highest for instrument manufacturers (2.9987). The number in the parentheses shows the rate of innovation that is calculated as the number of innovations divided by number of employees. However, regarding the printing industry, they find that the LIE (0.0468) was higher than the SIE (0.0313) in 1982. Chiao's (1998) constructed a dynamic model to analyze Acs and Audretsch's empirical findings. His theoretical findings remained consistent with Acs and Audretsch's empirical findings that innovation behavior of small and large firms varies across industries. The Schumpeterian view argues that large enterprises support the exploitation of innovation opportunities (Acs & Audretsch, 1990).

In addition, Acs and Audretsch (1990) identify five factors that favor the innovative advantage of large firms. First, because it is costly, development can be carried on only by a firm that has the resources commonly associated with considerable size. Second, only firms that are large enough to attain at least temporary market power will choose innovation as a means for profit maximization. Third, R&D is a risky investment, small firms involved in R&D make themselves vulnerable by investing a large proportion of their resources in a single project. Their larger counterparts, however, can reduce the risk accompanying innovation through diversification into simultaneous research projects. Larger firms are also more likely to find an economic application of the uncertain outcomes resulting from innovation activity. Fourth, economies of scale in promotion and in distribution facilitate the penetration of new products, thus enabling

large firms to enjoy a greater profit potential from innovation. Fifth, an innovation that yields cost reductions of a given percentage results in higher profit margins for larger firms than for smaller firms.

Based on the literature, Web technology can bring about both positive and negative consequences that affect organizational performance. Positive consequences of Web technology, such as reaching a large number of customers, online marketing and sales, online transactions, and customization of messages, usually improve the performance of a company. On the other hand, there may be negative consequences as well, such as the costs of building and maintaining a Web site, shipping and handling costs for tangible goods, higher return rate of items sold on the Web, and increasing competitiveness. Rogers' (1995) theoretical model and Acs and Audretsch (1990) findings suggest that large organizations are typically the early adopters and, by being first in the field, they gain windfall profits.

Methodology

A pilot test was conducted to check the validity of the survey instrument, eliminate any ambiguity, and make appropriate changes according to respondents' suggestions. A targeted sampling technique was applied to select the final subjects. Commercial printing firms of the Midwest region of the United States that had Web sites were selected for the pilot test and the final study.

Questionnaires were sent to appropriate graphic communications professionals such as presidents or owners, vice-presidents, directors, and marketing managers of those firms. A seven-point Likert scale was used to measure the organizational performance. The seven-point Likert scale was designed as: (1) strongly disagree, (2) disagree, (3) somewhat disagree (4) no difference, (5) somewhat agree, (6) agree, and (7) strongly agree. Four financial indicators, including sales, profits, costs, and ROI were used to measure the financial performance. The three non-financial indicators include number of customers, merchandise return rate, and productivity related to marketing and sales functions. All seven indicators were combined to measure overall performance. The Spearman correlation, analysis of variance (ANOVA), and chi-square statistical methods were used to determine relationships between the frequency of Web modification for conducting B2C activities on the Web and three levels of performance (financial, non-financial, and overall) of commercial printing companies.

Findings

A total of 38 questionnaires out of 103 subjects were returned. The response rate was 36.89%. Table 1 exhibits the frequency of responses to the question on the size of a commercial printing firm. The size of a commercial printing firm was divided into three groups based on the number of employees. The companies that had more than 49 employees were grouped as large-sized firms. The companies that hired less than 20 employees were grouped as small-sized firms. The medium-sized firms included those companies who had more than 19 employees but less than 50 employees. There were more large-sized firms (63.16%) than medium-sized firms (23.68%) and small-sized firms (13.16%) in the study sample.

The Spearman correlation method was used to measure the association between the size of a commercial printing

Table 1: Frequency of Responses on Firm Size

Firm Size	Frequency	Percent	Valid Percent	Cumulative Percent
Small	5	13.16	13.16	13.16
Medium	9	23.68	23.68	36.84
Large	24	63.16	63.16	100.00
Total	38	100.00	100.00	

company and the three levels of performance (FP, NFP, OP). Table 2 demonstrates there was no significant association between the size of a company and any of the performance levels at $\alpha = 0.05$. The results did not support the directional hypothesis. The ANOVA test was performed to determine the difference in means among the small-sized, medium-sized, and large-sized firms. There was no difference in means. This finding would suggest that performance of commercial printing firms is independent of size when conducting B2C activities on the Web.

The chi-square analysis was performed to verify the results of the Spearman correlation and ANOVA statistics. Table 3 shows the results of chi-square data analyses that are consistent with Spearman correlation and ANOVA statistics. Results did not support the hypothesis. Note from Table 2 and Table 3 that though there was no significant correlation between the size of a company and any of the performance levels, the large-sized companies saw increase in sales. However, the costs for maintaining the web sites were more for large-sized firms than medium-sized and small-sized firms, so may offset profits to some degree.

Table 2: Association Between Performance Indicators and Size of Company

Performance Indicator	Spearman Correlation Analysis		ANOVA Method to test Difference in Means	
	Coefficient	p-value	F-Statistics	p-value
Financial Performance	-0.1704	0.3204	1.06	0.3593
Sale	-0.2184	0.1877	0.64	0.5342
Profits	-0.2229	0.1786	1.32	0.2797
Costs	-0.1238	0.4391	1.38	0.2653
Return on Investment	-0.1104	0.5216	0.96	0.3938
Non-Financial Performance	-0.1063	0.5251	0.60	0.5556
Number of Customers	-0.1318	0.4303	0.52	0.6006
Merchandise Return Rate	-0.1046	0.5319	0.61	0.5490
Sales & Marketing Productivity	-0.0713	0.6706	0.34	0.7114
Overall Performance	-0.1646	0.3375	0.92	0.4101

Note. Significance level $\alpha = 0.05$.

Table 3: Chi-Square Statistics to Validate the Results of Spearman Correlation

Size of Company Variables	df	Chi-Square	Significance
Financial Performance	1	0.0487	0.8253
Sales	1	3.1415	0.0763
Profits	1	0.0928	0.7607
Costs	1	1.3049	0.2533
Return on Investment	1	0.5994	0.4388
Non-Financial Performance	1	0.0000	1.0000
Number of Customers	1	0.1062	0.7445
Merchandise Return Rate	1	0.5991	0.4389
Sales & Marketing Productivity	1	0.0317	0.8587
Overall Performance	1	0.2408	0.6236

Note. The seven-point Likert scale was divided into two groups: (a) No Agreement (scale 1–4) and (b) Agreement (scale 5–7). The size of a company was divided into two groups: (a) Small- and Medium-sized companies and (b) Large-sized companies. Significance level $\alpha = 0.05$.

Conclusions

The findings did not match with Rogers' theory of diffusion of innovation. The performance of a company was independent of the size of a company for conducting B2C activities on the Web. Web technology is inherently different from other technologies. The large-sized companies did not gain windfall profits by being the first to use the technology. As a result, the size of a company was not statistically related to any of the three levels of performance. However, it was found there were more large-sized commercial printing firms (63%) that conduct B2C activities on the Web than medium-sized (23.68%) and small-sized firms (13.16%).

In relation to the consequences of an innovation model, it was concluded that the use of Web technology as a business tool among different sizes of a commercial printing firms brought undesirable, indirect, or unanticipated changes such as no significant improvement in financial, non-financial, and overall performances. No significant desirable, direct, or anticipated changes were found.

The results matched with the GAMIS/PIA study that suggested not many printing firms were making profits by conducting B2C activities on the Web. The findings showed similarities with the results of "The Ultimate E-commerce Study" and Durfee and Chen's study that e-commerce was not for everyone. Future research studies should be conducted over a larger population to determine which other factors are responsible for improving financial, non-financial, and overall performances of commercial printing firms related to e-commerce.

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This is a refereed article

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