Visual Communications Journal
2005

PRINT

has a ripple effect

Table of Contents

* ..Malcolm Keif served as a juror for the *Journal*, but did not review his own paper.
**. Jerry Waite served as the editor of this *Journal*. However, his article was submitted blindly
to the review committee.
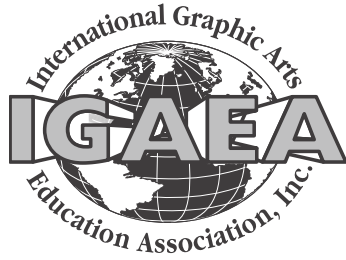
Visual Communications JOURNAL

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Acknowledgements

About the Journal

The *Visual Communications Journal* serves as the official journal of the
International Graphic Arts Education Association, Inc., and provides a
professional communicative link for educators and industry personnel
associated with design, presentation, management, and reproduction
of graphic forms of communication. Manuscripts submitted for publi-
cation are subject to peer review by the Association and the views and
opinions expressed herein are those of authors and do not necessarily
reflect the policy or the views of the IGAEA

Article Submission

Please follow the guidelines provided at the back of this *Journal*.

Membership and Subscription Information

Information about membership in the Association or subscription to
the *Journal* should be directed to the IGAEA Second Vice-President.

Editor's Note

After a four-year hiatus from the *Visual Communications Journal*, during which I served as the President of the IGAEA and hosted our 2004 Conference, I am very pleased to again edit the 2005 *Journal*. I'd like to thank both Charles Johnson and Mark Snyder for their superb work as editors during my absence.

This year, the *Journal* includes seven articles submitted by IGAEA members. Two of the articles document original empirical research while the other five offer concrete hands-on information that graphic arts educators can use in their classrooms.

Perhaps the IGAEA's most prolific researcher, Dr. Yung-Cheng Hsieh audited the attributes and characteristics of Taiwan's premiere printing firms in what he hopes will be the first step in creating standards, similar to GRACoL, for his nation's printing industry. He is particularly concerned about quality standards since Taiwan's admittance into the World Trade Organization in 2001 has forced its printing industry to encounter global competition. To increase the industry's competitiveness, Taiwan's printers must enhance their print quality to expand overseas markets and draw international business.

Dr. Tom Spotts looks at the efficacy of using densitometers to measure dot gain on printing plates. Spotts notes that, "In the past, the use of a densitometer to measure a plate was considered inaccurate based on the lack of sufficient density difference between the image and non-image color of the plate." However, recent announcements by densitometer manufacturers have contradicted that view. So, with the help of his graduate assistant, Nitin B. Desai, he designed and carried out an experiment to determine the accuracy of densitometric measurement of dot size on plates and press sheets. By physically measuring halftone dots with a microscope and comparing the measured size against densitometric readings of the same dots on a plate, he found very little disagreement. This, he argues, "serves to reinforce the potential of using a densitometer for monitoring dot area on a lithographic plate, a current need when using CTP systems."

Malcolm Keif and Tom Goglio, in their article on identifying high-volume printing processes, provide graphic arts educators with a concise and highly user-friendly method for identifying the particular process used to print a given job. Easy-to-identify images, coupled with clear and concise verbal descriptions, will help graphic arts students identify the characteristics inherent in images produced by various printing methods.

Eric Weisenmiller provides an excellent overview of the new RAW format for digital photographs. This article will provide both faculty and students with important information on the structure of RAW files as well as both the pros and cons of this powerful digital format.

Dan Wilson and Klaus Schmidt tackle the challenge of incorporating instruction regarding database technology into graphic arts programs. Perhaps considered more of an Information Technology problem than a graphic arts issue, Wilson and Schmidt argue that a solid knowledge of database technology is essential because it "has not only become a revenue source for printing companies, but is an essential requirement for automated quotes, file transfer and preflight, automated print production, variable data printing, and management information systems."

Lesta Burgess and Ronald O'Meara look at Internet-based instruction and its impact on the perceptions and attitudes of graduate students. Given the current push toward Internet delivery of coursework, Burgess and O'Meara surprisingly discovered that "67% of the students (surveyed) have never taken a web-based course." Even more enlightening is their conclusion that "students like taking some coursework via distance education to earn a degree, but prefer having the traditional method of face-to-face delivery and classroom interaction for the majority of their courses." Perhaps students really do acknowledge the value of a real live instructor!

My colleagues and I prepared the last paper included in this year's *Journal*. We provide graphic arts and photography educators with a very powerful, yet surprisingly simple, method for teaching students about white balance using presets available in most contemporary digital cameras. In addition, step-by-step instructions are given for setting up and conducting a lab session in which correctly and incorrectly balanced photos are captured and corrected.
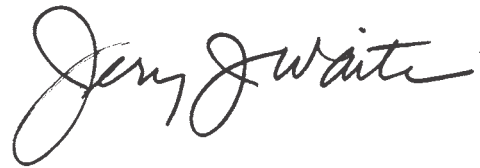
It is important to note that two articles in this *Journal*

were written by those involved in the editing and/or reviewing of the articles. Malcolm Keif served as a juror. However, he did not review his own paper. Instead, all four other jurors blindly reviewed it and their votes were tabulated to determine that his paper should indeed be published as a juried article. Similarly, Jerry Waite, who served as the *Journal*'s editor, and his colleagues

submitted their paper to blind review by all five jurors. Documentation regarding the voting on these two articles is available by contacting Jerry Waite at **jwaite@uh.edu**.

Several new jurors joined the staff of the *Journal* this year. They include: w, again served as a juror. Thanks to all five of these well-respected individuals for spending their time to critique the work of their peers.

A Study of Printer Characteristics and Print Attributes for Taiwan's Sheetfed Lithographic Industry

by Yung-Cheng Hsieh, Ph.D., Chair

Introduction

Sheetfed offset lithography is the most widely used printing process by Taiwan's printing industry, but there are no industry-wide specifications for press control to assure consistent quality across printing plants. As printing becomes more of a commodity and less of an art, it is necessary to understand the industry characteristics and develop its print quality specifications.

Statement of the Problem

Taiwan's admittance into the WTO (World Trade Organization) in 2001 has forced its printing industry to encounter global competition. To increase the industry's competitiveness, Taiwan's printers must enhance their print quality to expand overseas markets and draw international business. Competition from printers in North America, Europe, and Japan raises questions for Taiwan's printers: What are the strengths, weaknesses, opportunities, and threats of this industry, especially in the area of print quality? What are the printer attributes and print quality levels of Taiwan's sheetfed offset printing industry in comparison with those of other nations? This is a particularly important question for the commercial sheetfed lithographic industry in Taiwan because it accounts for more than 70% of the nation's total print production.

Needs and Purposes for the Study

Unfortunately, there are no printer characteristic profiles or print attribute specifications available in Taiwan. In some developed countries, there are quality standards and/or print attribute specifications developed by the printing industry or research institutions. These include GRACoL, SWOP, ShOPS, SNAP, FIPP, UKONS, and BVD/FORGRA. The author strongly believes that Taiwan's printing industry now needs to develop a set of printer characteristic profiles and print attribute specifications so that it can compete globally. Therefore, this study aimed to develop such profiles and print attributes.

Limitations of the Study

The following limitations must be considered when interpreting the results of this study:

- The participants were not randomly selected; instead they volunteered to partake in the study.

- No two printing systems were the same; a wide variety of presses were employed for this research. The make, age, number of units, and physical condition of the presses differed. Their effects on the results were not discussed.

- Pressroom temperature and relative humidity were not controlled; hence, they were not considered constant variables. Their effects on this research were not studied.

- The printing plates, blankets, fountain solution, and other press materials were not controlled. Their effects on the results of this study were not explored.

- The in-house density aim-points differ; they were measured and controlled by the participants with their own densitometers.

- The platemaking process and actual pressruns of the participants for this study were not observed due to budget and travel constraints.

- Participating companies had their own press crews; hence their working performances were uncontrolled and not investigated.

- Several brands and weights of paper were used for the study. Differences in the printing attributes of the individual stocks were not investigated. However, for final analysis, the samples were divided into two subgroups, coated and uncoated paper.

Methodology

This study was designed to explore the characteristics of Taiwan's commercial offset lithographic industry and then establish realistic print attribute specifications for the industry. In the first stage, a questionnaire was developed and administered to survey local high-quality sheetfed offset lithographic printing companies. The results were then categorized by company age, number of employees, company location, type of presses, printing color sequence, type of scanners, type of plates, and type of paper used for this experiment.

In the second stage, a true experiment was carried out. Participants were provided with a digital test form on a CD-ROM or a set of conventional litho films and asked to print 100 sheets according to their own in-house density aim points and standard operating procedures and conditions. The dependent variables of this study include densitometric attributes such as solid ink density, dot gain, print contrast, ink trapping, as well as hue error and grayness. All the printed samples were then measured and data were analyzed using SPSS and Minitab statistical software packages.

Sampling

The target population of this study was high quality commercial sheetfed lithographic printers in Taiwan. The criteria for selecting the participants in this study as high quality were: printers were active member companies of PIT (Printing Industry of Taiwan) or PTRI (Printing Technology Research Institute); they established themselves as commercially successful printers; and they were quality-conscious enough to have invested considerable time, materials, and effort in participating in this study without monetary compensation.

More than 50 high-quality commercial sheetfed lithographic printers were recommended by the PIT or PTRI. They were called by the author and invited to participate in the experiment. A total of 33 companies—representing 21 from the north, 4 from central, and 8 from the south of Taiwan—submitted a total of 95 sets of printed samples for this study. Companies were asked to submit samples on both coated and uncoated paper, but not all of the participants submitted both stocks: forty-five sets were printed on coated paper and 40 sets on uncoated paper. Each participant was asked to submit at least 100 printed sheets on both coated and uncoated stocks. Each stock was then randomly selected for a sample of 35 sheets each. Information about the participants (categorized by the company location and type of paper used) and their submitted sample sizes is displayed in Table 1.

The Test Form

A digital four-color test form was designed for this study. The test form is a 25"x35" press form that includes test targets and photographic images. The photographs on the test form are GATF test images that emphasize different color reproduction challenges. The other process characterization targets on the test form included: PTRI color control bar, GATF six-color two-tiered control bars, ink coverage target, IT8.7/3, CMYKRGB and 3K solid patches, tone scales of CMYKOG, color correction target, gray balance chart, CMYKRGB and 4K tint patches (5%~100%, in a 5% interval), and micro line target.

The test form was available on either a CD-ROM (containing TIFF files) or on conventional film. A service bureau produced 10 sets of conventional film in one day. The imagesetter utilized to output the film for this study was calibrated and linearized before the research. The imagesetter was a Screen FT-R 3050, and the measurement of dot area on the film was done with an X-Rite™ 341 transmission densitometer. This densitometer was also used for the imagesetter calibration and linearization. Before distributing the film to the participants, the 50% dots on the film were measured to ensure linearization of the film. Both the service bureau that produced the film and the participants who requested the CD-ROM were asked not to apply any compensation curves to the test form.

Most of the printers had their own in-house plate-making facilities. Those who did not have in-house platemaking were asked to purchase the plates—either conventional photo-sensitive (PS) or computer-to-plate (CTP)—on their own.

Location		North	Central	South	Total
No. of Participants		21 companies	4 companies	8 companies	33 companies
No. of Sets Submitted	Coated	30 sets	7 sets	8 sets	45 sets
	Uncoated	25 sets	7 sets	8 sets	40 sets
No. of Sheets Sampled	Coated	1050 (30×35)	245 (7×35)	280 (8×35)	1575 sheets
	Uncoated	875 (25×35)	245 (7×35)	280 (8×35)	1400 sheets

Table 1. The information about the participants and their sample sizes

Research Procedure

After receiving the test form, participants were asked to output the test form at 175 lpi screen ruling or to make PS plates using provided films. They were also asked to complete a questionnaire. The questionnaire consisted of two categories: company basic information, including location, age, current number of employees, current assets, previous year's revenue, and prepress and press equipment; and pressrun-related conditions related to this research, such as type of press, ink, print color sequence, type of plates (PS or CTP), type of coated paper, type of uncoated paper, and pressroom temperature and relative humidity.

There was no opportunity to inspect the printing plates used by those who requested conventional film. The participants were asked to print to their in-house density aim-points and proofs of the test form were not supplied. After target densities were achieved across the press, 100 samples were labeled and sent to the author. Each participant was asked to submit at least two stocks, one coated and one uncoated. All participants used four- or six-color presses to print the test form for the research. The weight of the paper was limited to 150 to 175 lb for the coated and 100 to 125 lb for the uncoated stocks. It took more than six months for the collection process, from contacting potential participants to receiving the printed samples.

Data Collection

One hundred printed sheets were submitted from each press run and 35 of them were systematically and randomly sampled. A total of 1575 printed sheets of coated and 1400 sheets of uncoated stock were sampled for this study. Status "T" density readings were made on these samples with a GretagMacbeth D118C color reflection densitometer using the Murray-Davies equation (n=1). Solid ink density, dot gain (10%, 20%, 25%, 30%, 40%, 50%, 60%, 70%, 75%, 80%, 90%), print contrast (75%), ink trapping, and hue error and grayness were measured. SPSS 11 and Minitab 13 statistical software packages were used for analysis. It is important to note that each specific patch on the sampled sheets was measured only one time due to time constraints.

Results and Findings

This section reports the overall results and findings obtained through analysis of the data. The results are categorized into two major parts: the characteristics of the printers and the print attribute specifications used by the participants. Each sub-section gives a brief description of a particular print attribute and its specifications.

Printer Characteristics

This section describes the results of the questionnaire which revealed the characteristics and printing conditions of the participating companies. The results of printer characteristics are summarized in Tables 2–10. Thirty-four high quality sheetfed lithographic printers participated in this research, but one of them was excluded due to the excessive density of solids. Among these 33 participants, 21 (63.6%) companies were located in the north, four (12.1%) from central Taiwan, and eight (24.2%) from the south (see Table 2). No participant from the east coast of the island was represented. Table 3 categorizes the participants by how long the company had been established. A high percentage of companies (33.3%), compared with the other categories, had been in business between 21–30 years. The participants' revenues in the year 2001 are displayed in Table 4. Table 5 categorizes the participants by the numbers of employees: it shows that approximately half of the participants (49%) have fewer than 25 employees. According to Table 6, most press systems owned by the participants were Heidelberg (45%), followed by Komori (19%), Mitsubishi (18%), Man Roland (12%), Akiyama (3%), KBA (2%), Man Miller (1%), and Planeta (1%). Table 7 specifies the printing systems that the participants used to run the test form for this study: Heidelberg (33%), Mitsubishi (27%), Komori (24%), Man Roland (7%), Akiyama (4%), KBA (2%), and Planeta (2%).

According to the survey, seven participants in this study owned CTP systems, including Heidelberg, CreoScite, Cymbolic, and others. Of the 45 coated sets, 30 (66.7%) were printed with PS plates, nine with thermal CTP, three with photopolymer CTP, and three with silver-halide CTP (see Table 8). Most participants owned Dainippon Screen, Linotype-Hell, Agfa, and Fuji scanners. Agfa, Scitex, Appollo, Screen, and Heidelberg imagesetters were used to run daily production. None of samples were printed with stochastic screens or hybrid screens.

Japanese inks, such as DIC, Tiger, Butterfly, Toyo, 4CS, and Hyeco were mostly employed to run the test form. The paper used by the participants for this study included three types of coated paper—gloss, matte, and double

sided coated—and three types of uncoated paper—wood-free printing and writing grades A and B, and machine finished. Eighty-nine percent of the coated sets (see Table 9) and 90% of the uncoated sets were printed using the K-C-M-Y color sequence, followed by K-M-C-Y, C-M-K-Y and Y-M-C-K.

Company Location	No. of Company (%)
North	21 (63.6%)
Central	4 (12.1%)
South	8 (24.2%)
East	0 (0%)
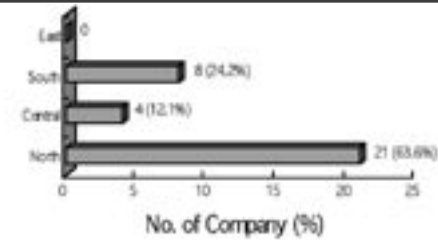
Table 2. Company location

Age of Company	No. of Company (%)
Below 10 years	5 (15.2%)
11-20 years	6 (18.2%)
21-30 years	11 (33.3%)
31-40 years	2 (6.1%)
41-50 years	5 (15.2%)
Over 51years	4 (12%)
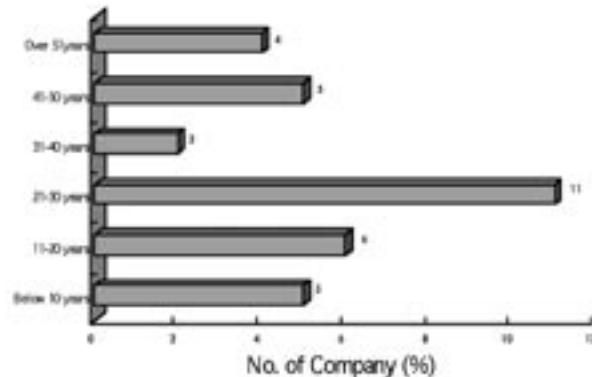
Table 3. Years companies have been in business

Revenue in 2001	No. of Company (%)
Below 5,000M NT$	12 (37.5%)
5,000M~10,000M NT$	7 (21.9%)
10,000M~20,000M NT$	6 (18.8%)
20,000M~30,000M NT$	2 (6.2%)
30,000M~40,000M NT$	3 (9.4%)
Over 50,000M NT$	2 (6.2%)
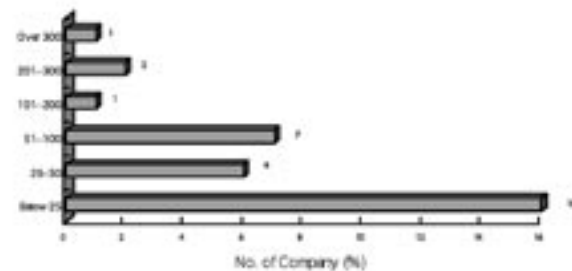
Table 4. Revenue of 2001

   Note: The asset values of most participants were more than 500M (only two below).

No. of Employees	No. of Company (%)
Below 25	16 (48.5%)
26~50	6 (18.2%)
51~100	7 (21.3%)
101~200	1 (3%)
201~300	2 (6%)
Over 300	1 (3%)
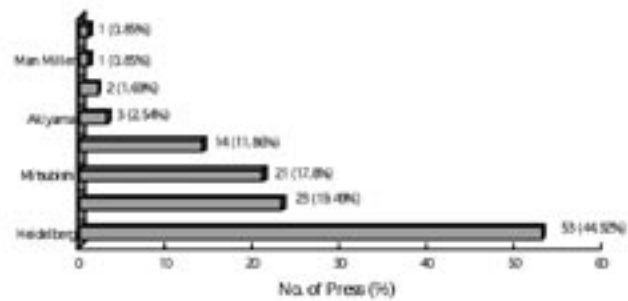
Table 5. Number of employees

Press Type	No. of Press (%)
Heidelberg	53 (44.92%)
Komori	23 (19.49%)
Mitsubishi	21 (17.8%)
Man Roland	14 (11.86%)
Akiyama	3 (2.54%)
KBA	2 (1.69%)
Man Miller	1 (0.85%)
Planeta	1 (0.85%)
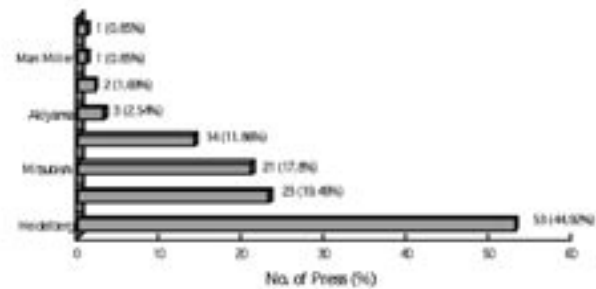
Table 6. Type of presses owned

Press Type	No. of Press (%)
Heidelberg	15 (33.3%)
Komori	11 (24.4%)
Mitsubishi	12 (26.7%)
Man Roland	3 (6.7%)
Akiyama	2 (4.4%)
KBA	1 (2.2%)
Planeta	1 (2.2%)
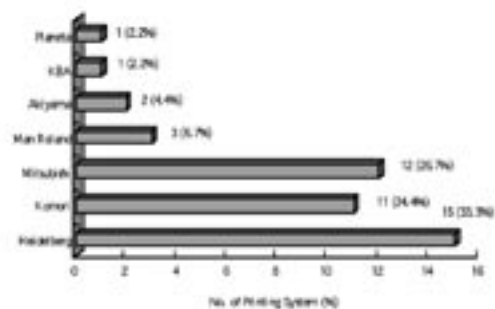
Table 7. Type of printing systems used for this study

Plate Type	No. of Plate (%)
Conventional PS	30 (66.7%)
Silver Halide CTP	3 (6.7%)
Photopolymer CTP	3 (6.7%)
Thermal CTP	9 (20%)
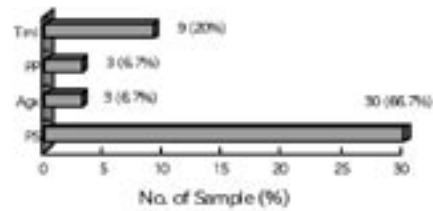
Table 8. Type of plates used for this study

500M. (only two below)

Sequence Type	No. of use (%)
K-C-M-Y	39 (88.6%)
K-M-C-Y	3 (6.8%)
C-M-K-Y	1 (2.4%)
Y-M-C-K	1 (2.4%)
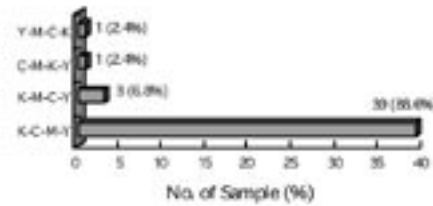
Table 9. Printing color sequence used for this study (printed on coated paper)

Type	No. of Company	Description
B/W Scanner	8	Including Dainippon Screen, Linotype-Hell, Scitex, Agfa, Fuji, ECRM. Most owned brands were Agfa and Fuji.
Flatbed Scanner	20	Including Crosfield, Agfa, Linotype-Hell, Scitex, Fuji. Most owned brands were Agfa (8), followed by Scitex (5).
Drum Scanner	12	Including Crosfield, Dainippon Screen, Linotype-Hell, Agfa. Most owned brands were Linotype-Hell (6), followed by Dainippon Screen (5) and Agfa (4).
PC Prepress Work Station	22	All companies owned less than 10 stations in the shop.
Mac Prepress Work Station	25	All companies owned less than 20 stations in the shop
Imagesetter	21	Including Agfa, CreoScitex, Appollo, Scitex, Screen, Heidelberg. Most owned brands were Agfa (13), followed by Scitex (6).
CTP System	7	Including Agfa, Heidelberg, Scitex, Cymbolic.
Ink Used for Daily Production		Japanese inks were the main category including DIC, Tiger, Butterfly, Toyo, 4CS, Hyeco, etc.
Press Room Temperature		Between 21 °C and 30 °C, the average was 24.1 °C (75 °F)
Press Room Relative Humidity		Between 40% and 66%, the average was 56.92%

Table 10. Equipment and materials used

	Paper Type	Y	M	C	K
Solid Ink Density	Coated Paper	1.3937 ± 0.0095	1.2512 ± 0.0062	1.6856 ± 0.0119	1.7098 ± 0.0152
	Uncoated Paper	1.0342 ± 0.0078	0.9464 ± 0.0066	1.1086 ± 0.0084	1.1075 ± 0.0102

Table 11. Print attributes for solid ink density

Print Attributes

This section discusses the descriptive statistics of the data. The means are given as a value ± the margin of error of the mean calculation. For this study, the margin of error is a statistic derived from computing the 95% confidence interval of the mean.

Solid Ink Density (SID)

In the printing industry, density usually refers to the ability of a print to absorb light. The darker a process color is to the eye, the higher the density. In terms of quality, monitoring SID during a press run is essential when comparing any printed material. Many research reports have indicated that SID has a greater influence on dot gain than any other factor. The higher the SID printed for a given condition, the more the midtone gains in density. As the midtone gets darker, shadow contrast decreases and the shadows get denser. Increasing the ink on the paper may therefore not give the desired result to a reproduction. In addition, as more ink is applied, the bump in the curve moves toward the highlight, causing even more loss of shadow contrast and a general darkening of all the midtone. The optimum SID will give the highest contrast without flattening the shadow contrast. The SID attribute obtained in this study was displayed in Table 11.

Dot Gain

Dot gain, or tonal value increase, occurs when creating prints from film to paper. In this study, it was calculated using "% print dot - % film dot." Total dot gain is the difference between the dot area of the film, as measured with a transmission densitometer, and the dot area of the proof or printed sheet, as measured with a reflection densitometer. Due to technical reasons and the effect of light entrapment, printing without dot gain is impossible. It has been recognized that dot gain is one of the most critical factors associated with printing quality in the lithographic process. For many years, it has been one of the most important measured values for quality improvement and standardization in the printing industry (Hsieh, 1997).

Table 12 depicts the 10%–90% dot gain statistics for the coated and uncoated samples. The average dot gain values of coated papers showed that cyan had the greatest dot gain, followed by black, yellow, and magenta at 10% and 20% tone values; black had the greatest dot gain values at 30%–90% tints. The average dot gain values of the uncoated paper shown in Table 12 revealed that black had the largest amount of dot gain size at all tone values (10%–90%), followed by yellow, cyan, and magenta. In addition, the least amount of dot gain occurred in magenta at 10%–60% and in cyan at 70%–90%.

The dot gain curves of for 10%–90% dots are exhibited in Figure 1. It illustrates that uncoated paper (dashed curves) had greater dot gain than coated paper (solid curves) at all tone values in all colors. Furthermore, it shows there are two commonalities between the two stocks: (1) the greatest dot gain occurred at 40-60% film dots, and (2) black ink had the greatest dot gain amount and magenta had the least.

Tone value	Paper Type	Y	M	C	K
10% tints	Coated Paper	5.467 ± 0.1684	4.531 ± 0.1381	5.779 ± 0.1611	5.673 ± 0.1596
	Uncoated Paper	8.204 ± 0.2095	7.299 ± 0.2077	7.822 ± 0.2364	9.177 ± 0.2310
20% tints	Coated Paper	9.7930 ± 0.2444	7.7181 ± 0.1665	10.213 ± 0.2265	10.043 ± 0.2496
	Uncoated Paper	13.950 ± 0.2535	11.866 ± 0.2257	13.159 ± 0.2675	15.335 ± 0.3049

Table 12. Print attribute for 10%~90% dot gain (continued on next page)

25% tints	Coated Paper	10.904 ± 0.2738	8.8311 ± 0.1863	11.538 ± 0.2560	11.588 ± 0.2904
	Uncoated Paper	15.246 ± 0.2704	13.251 ± 0.2340	14.649 ± 0.2732	17.139 ± 0.3227
30% tints	Coated Paper	11.620 ± 0.2943	8.957 ± 0.203	11.750 ± 0.2776	12.074 ± 0.3222
	Uncoated Paper	16.216 ± 0.2775	13.576 ± 0.2349	14.813 ± 0.2841	17.826 ± 0.3301
40% tints	Coated Paper	12.672 ± 0.3102	10.494 ± 0.2226	13.438 ± 0.2867	14.328 ± 0.3611
	Uncoated Paper	17.349 ± 0.2736	15.089 ± 0.2405	16.351 ± 0.2741	19.974 ± 0.3354
50% tints	Coated Paper	13.222 ± 0.3063	10.814 ± 0.2247	13.364 ± 0.2729	14.711 ± 0.3470
	Uncoated Paper	17.365 ± 0.2612	14.881 ± 0.2350	15.640 ± 0.2593	19.600 ± 0.3228
60% tints	Coated Paper	14.615 ± 0.275	12.568 ± 0.1990	14.435 ± 0.2564	15.660 ± 0.2992
	Uncoated Paper	17.971 ± 0.2281	15.774 ± 0.2057	16.064 ± 0.2423	19.650 ± 0.2488
70% tints	Coated Paper	12.495 ± 0.2539	10.270 ± 0.1867	11.472 ± 0.2300	12.862 ± 0.2553
	Uncoated Paper	15.206 ± 0.2036	12.871 ± 0.1825	12.666 ± 0.2149	15.914 ± 0.2070
75% tints	Coated Paper	10.983 ± 0.2343	9.0171 ± 0.1686	10.057 ± 0.2061	11.330 ± 0.2266
	Uncoated Paper	13.301 ± 0.1822	11.193 ± 0.1617	11.046 ± 0.1926	13.891 ± 0.1822
80% tints	Coated Paper	9.365 ± 0.2050	7.651 ± 0.1494	8.3020 ± 0.1765	9.490 ± 0.1964
	Uncoated Paper	11.236 ± 0.1584	9.4379 ± 0.1418	9.0564 ± 0.1688	11.534 ± 0.1549
90% tints	Coated Paper	5.036 ± 0.1372	4.279 ± 0.1146	4.3140 ± 0.1221	5.310 ± 0.1307
	Uncoated Paper	5.8107 ± 0. 1152	5.0964 ± 0.1074	4.4114 ± 0.1348	6.2321 ± 0.1056

Table 12. Print attribute for 10%~90% dot gain (continued from previous page)
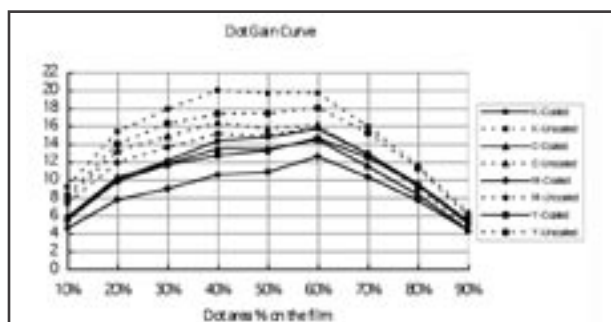
 Figure 1. 10%~90% dot gain curve

Dot Gain Ratio

Another interesting finding from examining dot gain data is that, regardless of the actual 50% dot gain, the ratio of the 50% dot gain to the 25% dot gain remained relatively constant between all ink colors and types of paper (See Table 13). Dot gain ration is calculated by simply dividing the 50% dot gain by the 25% dot gain. The 50/25 ratios for all four colors are very similar, with no more than 0.10 range for both the coated and uncoated stocks. There was also relative consistency across paper types. Therefore, the 50/25 dot gain ratio can be simplified to just 1.27 for all ink colors on coated paper, and 1.16 for all ink colors on uncoated paper. Given a specific 50% dot gain value, the 25% dot gain value can be easily calculated by dividing by the 50/25 ratio.

The ratio between the 50% dot gain and the 75% dot gain was also found to remain relatively constant between all colors. Since the 50/75 ratios of the coated paper were within 0.1 point of the overall average, this study suggests that the 50/75 dot gain ratio be simplified to just 1.28 for all ink colors on coated paper. Although the 50/75 dot gain ratio of the uncoated paper gave slightly higher than average ratios compared to the overall averages for all ink colors, the differences were still within 0.1 point of the overall average. Hence, this study suggests that the 50/75 dot gain ratio be simplified to 1.38 for all ink colors on uncoated paper.

	Paper Type	Y	M	C	K	Overall Average
50:25 Dot Gain Ratio	Coated Paper	1.2623 ± 0.023	1.2807 ± 0.024	1.2467 ± 0.033	1.2951 ± 0.016	1.27 ± 0.02
	Uncoated Paper	1.1747 ± 0.013	1.1559 ± 0.015	1.1524 ± 0.035	1.1692 ± 0.010	1.16 ± 0.02
50:75 Dot Gain Ratio	Coated Paper	1.2366 ± 0.019	1.2200 ± 0.016	1.3676 ± 0.018	1.2918 ± 0.016	1.28 ± 0.02
	Uncoated Paper	1.3157 ± 0.011	1.3432 ± 0.013	1.4716 ± 0.021	1.4031 ± 0.012	1.38 ± 0.01

Table 13. Print attributes for dot gain ratio

Print Contrast

Print contrast (PC) is a measure of shadow contrast and is the degree to which viewers can distinguish printed tones in the shadow area of a reproduction. In other words, PC is an objective characteristic of printing relating to the shadow detail rendered by the process. PC is calculated in a manner that compares density reading differences between a three-quartertone tint area (usually a 75% or 80% tint) and a solid patch. The formula is:

$$\% \ PC = \frac{D_s - D_t}{D_s} \times 100$$

D_s = Density of the solid patch (including paper density)

D_t = Density of the three-quartertone patch (including paper density) (Tritton, 1997).

Table 14 shows the average print contrasts found in this study. For both coated and uncoated paper, the greatest print contrast was found in cyan (51.3% for coated and 37.2% for uncoated paper). The second largest print contrast value was found in black (50.9% and 33.0% for coated and uncoated paper, respectively).

Ink Trapping

Ink trapping is a print attribute that relates to the two-color overprint colors of blue, green, and red. It estimates the amount of ink that is transferred to a previously printed ink film compared to the transfer of ink to an unprinted substrate. The print sequence must be known to make trapping measurements (Stanton, 1991). There are various equations used to calculate ink trapping, but the Preucil trapping equation is the most frequently used and was applied for this study:

$$Trap \ (\%) = \frac{D_{1+2} - D_1}{D_2} \times 100$$

where $D_1 + _2$ = density of the overprint

D_1 = density of first color

D_2 = density of second color (Tritton, 1997).

In the lithographic industry, accepted trapping is generally somewhere between 75% and 95%: the higher the percentage, the better the ink trapping. Since approximately 90% of the submitted stocks (89% for coated sets and 90% for uncoated) were printed with the C-M-Y-K

	Paper Type	Y	M	C	K
Print Contrast	Coated Paper	42.702 ± 0.41	42.696 ± 0.27	51.314 ± 0.34	50.898 ± 0.38
	Uncoated Paper	30.342 ± 0.36	32.219 ± 0.30	37.221 ± 0.34	32.956 ± 0.38

Table 14. Print attributes print contrast

	Paper Type	Red-MY Overprint	Green-CY Overprint	Blue-CM Overprint
Ink Trapping %	Coated Paper	69.684 ± 0.29	84.332 ± 0.25	82.626 ± 0.31
	Uncoated Paper	55.090 ± 0.26	81.249 ± 0.19	67.486 ± 0.32
Note: Printing color sequence: K-C-M-Y; Coated samples = 1400 (40 sets * 35 sheets); Uncoated samples = 1260 (36 sets * 35 sheets)				

Table 15. Print attributes for ink trapping

color sequence, this study only investigated the trapping values for that sequence (as shown in Table 15). Table 15 reveals that the average trapping values of coated paper were higher than those of uncoated paper in all of the red, green, and blue traps. For both coated and uncoated paper, the green trap (cyan-yellow overprint) had the largest trap value, followed by blue (cyan-magenta overprint) and red trap (magenta-yellow overprint).

Hue Error and Grayness

As previously mentioned, ideal process color inks should each absorb approximately one-third of the visible spectrum and reflect the other two-thirds; however, it is not economically feasible to produce ideal (pure) printing inks. Therefore, printers have to accept a certain amount of contamination in process inks. Contamination is not necessarily bad as long as contamination levels are held consistent. For this reason, hue error and grayness are usually calculated to measure and control the amount of contamination present in printing inks.

A typical reflection densitometer has three filters used to measure the densities of the four process colors. By putting one of these filters in between the reflective
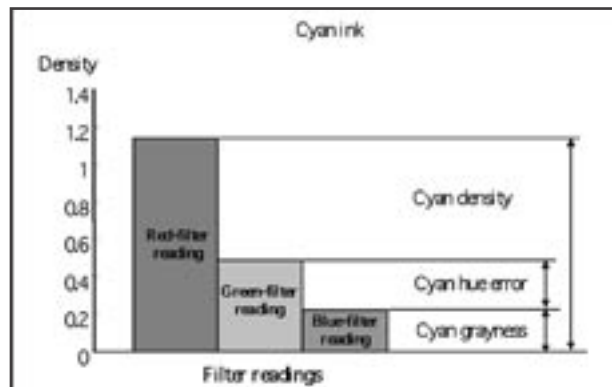
Figure 2. An illustration of hue error and grayness

Source: "Handbook of Graphic Arts Equations" by Manfred H. Breede, 1999, Pittsburgh, PA: GATFPress.

surface (ink and paper) and the collecting optics, the densitometer can determine which color is being measured. By way of example, assume that all ink is made with different proportions of cyan, magenta, and yellow. By measuring an ink through each individual filter, an ink profile can be made up to illustrate the amount of each color present in the ink (Tritton, 1997). As shown in Figure 2, cyan ink not only contains the color cyan, but also contains some amounts of magenta and yellow. These portions of yellow and magenta are the contaminating portions of the cyan ink.

The calculations of hue error and grayness are made from density readings taken from each ink through all three densitometer filters. The highest density is always measured through the complementary filter of the nominal color being measured. Thus, cyan, magenta, and yellow will always have red-, green-, and blue-filter values as their highest density values, respectively. See Table 16.

The calculations of hue error and grayness are functions not commonly found on densitometer manufactured in Europe but are frequently found on instruments from the USA, where the measurement was developed by Prucil at GATF (Tritton, 1997). The equations are shown below:

$$\text{Hue Error (\%)} = \frac{D_m - D_l}{D_h - D_l} \; ? \; 100$$

$$\text{Grayness (\%)} = \frac{D_l}{D_h} \; ? \; 100$$

Where D_l is the low filter reading, D_m is the middle filter reading, and D_h is the high filter reading

The overall results of the hue errors and grayness of this study are displayed in Table 17. It is important to mention that hue error and grayness were used for comparative purposes only. Both hue error and their grayness values of the coated paper were lower than those of the uncoated paper in all of the cyan, magenta, and yellow

Solid Ink Color	Blue Filter (Yellow)	Green Filter (Magenta)	Red Filter (Cyan)
Cyan	Low	Middle	High
Magenta	Middle	High	Low
Yellow	High	Middle	Low

Table 16. Solid density readings through three filters

Source: "GATF 19×25-in. Sheetfed Color Printing Test Kit User's Guide" by Anthony Stanton, 1991, Pittsburgh, PA: GATFPress.

	Coated Paper		Uncoated Paper	
Color	Hue Error %	Grayness	Hue Error %	Grayness %
Y hue error to M	3.0019 ± 0.04	1.1276 ± 0.04	4.2814 ± 0.04	1.2086 ± 0.04
M hue error to Y	51.464 ± 0.19	4.8095 ± 0.05	56.211 ± 0.16	5.8336 ± 0.07
C hue error to M	26.234 ± 0.11	8.7283 ± 0.04	35.118 ± 0.15	12.962 ± 0.07

Table 17. Print attributes for hue error and grayness values

inks. Coudray (1997) suggested that typical hue error and grayness values for process color inks are as follows: yellow hue error to magenta = 2~5%, grayness = 2~5%; magenta hue error to yellow = 35~74%, grayness = 9~15%; cyan hue error to magenta = 18~26%, grayness = 18~26%.

Conclusions

The author believes that a comprehensive profile of realistic quality specifications should be based on best-practices of existing high-quality printers to assure that they represent attainable values and reflect high-quality output. The result of this research is a realistic profile, based on real-world operating parameters by major sheet-fed offset lithographic printers in Taiwan. The printer characteristics and print attribute specifications contained herein provide the Taiwanese commercial sheetfed lithographic printing industry and graphic communications researchers with useful guidelines. In particular, the results of this study represent a coherent and attainable set of aim points and tolerances and are useful information for setting print quality standards for the commercial sheetfed offset lithography in Taiwan.

Since print attribute specifications for high quality commercial sheetfed lithography in Taiwan have not been studied prior to this research, these results provide Taiwanese printers with a very useful and practical reference for comparing their own specifications with others across the country. Another distinguishing feature of this study is the procedure and model of establishing print attribute specifications for the sheetfed lithographic industry. These procedures and ideally be used by printers to develop their own in-house specifications.

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A Comparison: The Measurement of Dot Area by Densitometry and Physical Measurement Methods

by Dr. Thomas H. Spotts and Nitin B. Desai

Introduction

The use of dots to reproduce continuous tone images in printing is an established practice. Typical printing processes are only able to print high contrast images and as a result employ the halftone process to convert continuous tone images—i.e. images made up of a full range of tones from no color at all to solid color—into a series of high contrast dots. In the conventional screening process, gradations of tone from light to dark are represented by changing the area that the dots cover. The percent area that the dots cover then represents the highlights, midtones, and shadows of a continuous tone image.

When halftone dots are reproduced, they do not print at their true value. This is true of conventional lithographic printing and digital printing devices (Waite, 2003). For a variety of reasons, the dots get larger and effective dot area gains in value as they proceed through the printing process. This is referred to as dot gain or tone value increase. For the purposes of this paper, dot gain is defined as the difference in the apparent dot area of the print and the apparent dot area of the film (Brehm, 1992). Printers are able to monitor this change through the use of densitometry. Traditionally, they measured the dots on the press sheet and compared their size to the size of corresponding dots on the negative to determine dot gain. Measurement of the dots on the plate was not deemed necessary. With the platemaking process standardized, printers were content to characterize dot gain by measuring the film and press sheet.

Computer-to-plate (CTP) technology does not use film, so the printer has no dot-area base line to compare (Romano, 1996). Therefore, to examine press gain, the need to measure plate dot area in CTP systems is evident. Reflection densitometry offers a method to measure plate dot area. In the past, the use of a densitometer to measure a plate was considered inaccurate based on the lack of sufficient density difference between the image and non-image color of the plate. Other methods of determining dot area on a plate, such as using a planimeter or image analysis, were lab procedures considered cost prohibitive. Though using densitometers to measure density on plates is questioned, newer densitometers claim the ability to accurately and consistently measure dot area on lithographic plates.

For a number of years, the concept of monitoring dot gain with densitometry has been introduced to the author's students by a project where they print a screen-tint guide lithographically and measure the tint patches with a reflection densitometer. The guide consists of tints from 0 to 100% in 10% increments at 85, 100, 110, 133, 150, and 200 LPI screen ruling which allow students to examine differences in dot gain in the highlights, midtones, and shadows as well as the influence of screen ruling on dot gain. In Fall 2004, the author expanded the exercise to have students take additional densitometry readings. In the past, dot area comparisons were based on the assumed film tint values being correct as labeled. Now, in addition to press sheet measurements, students measure dot areas on the film with a transmission densitometer and dot areas on the plate with a reflection densitometer. In doing this, they monitor the source of dot area increase during the reproduction process and are introduced to reading the plate dot area using a densitometer, much as might be done when using a CTP system.

Since densitometer accuracy and consistency in reading dot area on plates is often questioned, the author undertook a small project to compare densitometry readings with physical dot area readings on a plate. With the limited equipment available, the author sought to physically measure the dot area on the negative, plate, and press sheet and verify the results obtained with the densitometers. This article documents the procedure used and the results of the comparison with densitometry readings.

Project

According to Stanton (1995), "using densitometers to measure plate dot area is controversial." Brehm (1992) states that emulsion colorants are not dark enough and plate colors are not light enough for suitable contrast to yield repeatable information. However, according to X-Rite (1996), utilizing adequate densitometer settings and procedures, consistent and reliable results are obtainable. This small project, undertaken with the aid of a graduate assistant, compared the physical measurement of dot area to the dot area results from the densitometer readings.

The reasons for conducting this project were to: 1) determine how a physical measurement of effective dot area compared to instrument readings on the plate; 2) offer some validation for the accuracy of densitometer plate readings; and 3) physically measure dot area on the negative, plate, and press sheet and compare these measurements to the densitometry readings. The goal of this project was to make physical measurements for comparison to instrument readings. The significance of the research is educational, since the accurate measurement of dot area using lab equipment, such as a planimeter or an image analysis system, has been documented in the literature. This project provides some evidence about what can be done with limited resources and facilities.

Procedure

Dots were measured on the negative, plate, and press sheet with both densitometer and microscope. Typical representative screen rulings were chosen: 85, 100, 110, 133, 150, and 200 LPI. The percentage dot areas measured for each line screen were selected at random: 20% at 85 LPI, 50% at 100 LPI, 30% at 110 LPI, 70% at 133 LPI, 40% at 150 LPI, and 90% at 200 LPI. These areas were measured on all the different media: film, plate, and press sheet. A properly calibrated transmission densitometer was used to measure the negative and a properly calibrated reflection densitometer was used to measure the plate and press sheet. Therefore, instrument agreement was assumed.

A negative of a screen-tint guide (round dot shape) was used to expose a plate and the plate was used to print a representative sample of press sheets. The experimental, or measurement, phase of the project involved three distinct steps.

- Measuring the dot area on negative, plate, and press sheet with the appropriate densitometer;

- Measuring the dot sizes and figuring dot areas on negative, plate, and press sheet using a microscope; and

- Comparing the dot areas from above two steps.

Densitometer Measurements

As described above, the authors chose typical line screens at 85, 100, 110, 133, 150, and 200 LPI primarily because these were the screen rulings on the screen tint test pattern used in the student project. At the screen ruling mentioned, the authors selected the percentage density samples Shown in Table 1:

Line screen	Percentage density of dot chosen
85LS	20%
100LS	50%
110LS	30%
133LS	70%
150LS	40%
200LS	90%

Table 1. Screen rulings and tint patches

Negative film measurements were taken with a Gretag D200-11 Transmission Densitometer calibrated as per manufacturer instructions. Ten different readings were taken on the negative with the transmission densitometer at each of the line screen samples chosen (as shown in the Table 1). The mean value of these ten readings was calculated for each line screen sample.

Effective dot area on the plate and press sheet was measured with an X-Rite 528 Spectrodensitometer, calibrated as per manufacturer specifications. A similar procedure was carried out for calculating mean value of dot area for the plate and press sheet. The respective samples on negative, plate, and press sheet were compared for their increase in the dot area.

For the densitometer measurements, the standard Murray-Davies equation was used in determining dot area. According to X-Rite (Wollney, 1996), the Murray-Davies formula is the most common calculation used to convert density measurements to dot area. A variation to this formula uses an adjustment value called the n-factor to compensate for optical gain caused by variations in substrates. However, the low contrast properties of printing plates do not seem affected by this (X-Rite, 1996). This fact was made apparent in a study by Graphic Arts Technical Foundation (GATF) in which a standard densitometer (Status T response) using the Murray-Davies formula was shown to be effective for conventional plate measurement (Stanton, 1995). Based on this finding, it was decided to set the densitometer to Status-T response and use the standard Murray-Davies dot area formula.

Physical Measurements

According to Romano (1996), halftone dot area measurement of plates has been traditionally done in a lab using a planimeter, an instrument that takes area readings of plane figures. He suggested video image analysis as an alternative, though some variables tend to make the process subjective (Romano, 1996). Having immediate access to neither, alternative methods were sought by the author for this project.

The department's Metallurgical Materials Testing Lab has an Olympus PME inverted metallurgical microscope with objective lenses of 10X, 20X, 40X, and 100X. One eyepiece had reticules so estimated measurements of dot size might be made. Measuring dot sizes physically with a microscope and estimating dot areas from this data was a little tricky. Since the microscope magnifies a small area (the viewing area contained few dots) and makes it difficult to estimate dot area, the authors had to measure dot size with the scope, enlarge the measured area, count the dots and calculate dot area covered for each surface in order to determine any change in the dot area on the respective surfaces, i.e. negative, plate, and press sheet. While using the microscope, the accuracy level of dot size measurement was maintained by using a known size line (UGRA Plate Control Wedge Microline Resolution Target) to estimate the distance of reticules on the eyepiece. Since the lens used to measure showed a discrepancy in the measurement by two microns—i.e. showing 68 microns instead of 70 microns—each measurement taken had to overcome this discrepancy through calculations to achieve a high accuracy level.

The dot sizes of all the screens on the negative, plate, and printed paper were measured in microns using the microscope. To maintain the accuracy level, ten different size readings were taken for each line screen sample with the microscope and average dot size was calculated.

To measure dot area for any specific area of any particular sample screen, a count of the number of dots in that area was required. The screen tint patches are only one half square inch and it was difficult to count the number of dots. The authors scanned and enlarged the patches at 600 DPI resolution to facilitate counting the dots. The half square inch patch was enlarged by 16 times its size (256 times its area) to achieve an eight-inch large square. This was then output on a printer. A one square inch area was then marked with pencil on the print and the number of dots counted. Given the size of dot for the particular line screen (measured under the microscope) and the number of dots in the area of that specific line screen sample, the authors figured the total dot area of that sample line screen in the given area. The area of each dot was calculated mathematically (πr_2 for round dots and $l \times w$ for square dots). The area of each dot was then multiplied by the number of dots in one square inch and divided by the area measured (1 square inch) to provide the ratio of dot coverage. Thus, if a particular dot covered .12 of the area, it was determined to be a 12% dot. Once the dot area calculations for the area were done for all sample screens, the effective dot area was estimated by percentage calculation method. After this was done for the negative, plate, and press sheet, the readings were compared for their percentage increase in the dot area.

Limitations of the Study

Since the dot area on the negative was measured with a transmission densitometer and the dot area on the plate was measured with a reflection densitometer, there can be doubt about agreement among instruments. Inconsistent readings could be the result of instrument variation. However, since the instruments were calibrated in accordance with manufacturer instructions, agreement was assumed.

The microscope objective lens preferred for the measurement of dot sizes exhibited, as mentioned previously, the discrepancy of two microns. So for every dot size measurement, this was taken into account and the authors tried to eliminate it. Scanning the samples and enlarging them to count the dots, even with special care, introduces opportunity for error and variation. It was easy to calculate the areas of circular dots, but as tints approached 50% the dots touched and appeared square. This made accurate calculations more difficult. The 133 LPI-70% and 200 LPI-90% screens showed high-density areas with no definite shapes. Therefore, for calculation purposes, the authors assumed a circular shape, which was difficult because the dot covered such a large area.

Dot sizes on the plates may have been affected by improper exposure time. The department's plate exposure unit with a light integrator was inoperable and the authors had to use a unit that was only equipped with a timer. Even though several exposure tests were performed, the exposure time determined may not have been accurate.

Optical gain is accounted for in the densitometer's dot area formula, but was not considered when the dots were physically measured. Optical dot gain occurs when light around the dot penetrates the paper, is reflected back under the dot, and is absorbed. Hence, the dot appears larger than it actually is.

Results and Discussion

The mean dot area of the densitometer readings for the negative, plate, and paper are shown in Table 2 and mean dot area of the estimated physical measurements is shown in Table 3. Dot area difference is provided in Table 4.

The results were not totally unexpected and offer an opportunity for drawing inferences. When measuring the negative, it was noted that the actual dot area on the negative tint patches was not always what the tint guide indicated. This is not unusual because of variance that occurs with imagesetters when outputting film as well as linearization inaccuracies. The negative was a duplicate negative made by multiple exposures (because the imagesetter sets only one screen ruling at a time), which might also account for some inaccuracy in the tint patches. However, since the negative readings provide a baseline, this point is of little importance. It should be noted that the physical measurements of the negative dot area

% Tint	Screen ruling	Negative	Plate	Press Sheet
20	85 LPI	19	22	30
30	110 LPI	29	33	45
40	150 LPI	39	45	62
50	100 LPI	49	55	67
70	133 LPI	71	77	86
90	200 LPI	94	98	99

Table 2. Percent dot area measured with densitometer

% Tint	Screen ruling	Negative	Plate	Press Sheet
20	85 LPI	19	20	24
30	110 LPI	28	31	33
40	150 LPI	40	44	53
50	100 LPI	50	53	57
70	133 LPI	70	75	76
90	200 LPI	90	99	100

Table 3. Percent dot area measured physically

% Tint	Densitometer Neg. to plate	Densitometer Neg. to Press	Physical Neg. to plate	Physical Neg. to Press
20	3	11	1	5
30	4	16	3	5
40	6	23	4	13
50	6	18	3	7
70	5	15	5	6
90	4	5	9	10

Table 4. Percent dot area difference

indicated accurate tints at 40, 50, 70, and 90%. The densitometer readings and physical measurements were within 1% of each other at the 30, 40, 50, and 70% tints, in agreement at 20%, and were 4% different at the 90% tint.

Dot area readings on the plate showed a similar pattern, with both physical and densitometer measurements being within 1 to 2% on each tint patch. At the 20% tint, the densitometer readings indicate the negative read 19%, and the plate was 22% while the physical measurement indicated 19% for the negative and 20% for the plate. This difference in the two measurement methods, considering limitations of the physical measurements, appear similar and in fact, is smaller than expected. The negative to plate differences in dot area are expected as a result of gain occurring during platemaking. Both measurement methods reflected this.

Dot area readings on the press sheet showed greater differences when comparing densitometer and physical measurements because the densitometer readings account for changes in dot size caused by optical phenomena whereas physical measurements account for only the physical size of the dot. As such, differences in the two methods ranged from 5 to 13%.

Summary

Looking at the measurements from both methods, dot area difference was what might be expected. Difference from negative to plate was near that which is documented in the literature (Bruno, 1988). Of course, dot gain measured by the densitometer and physical measurement were not in perfect agreement because of the difference in the two methods of measurement.

When comparing dot area change from negative to the plate, the results were expected though somewhat greater than the 2% usually attributed to platemaking. This may have been caused by inaccurate plate exposures as mentioned in the Limitations of the Study.

Dot area change from plate to press sheet were again near what could be expected. Dot area change as measured by the densitometer and by physical measurements was not in agreement when compared, but this can be accounted for by the phenomena of optical dot gain. Since optical gain can account for up to 12% additional increase over mechanical (Bruno 1986), it is not unusual for the densitometer readings to be different from the physical measurements on the press sheet.

This attempt to measure the actual dot area on the different surfaces had limitations that potentially impact the results when comparing the two methods, but the study still yielded some useful results. While the results of the two methods of measurement did not always agree, they were typically within 1 to 2% of each other except for the press sheet measurements, where, as explained, optical gain can account for the differences. This serves to reinforce the potential of using a densitometer for monitoring dot area on a lithographic plate, a current need when using CTP systems. It also serves to reinforce the optical dot gain phenomena as illustrated in literature (Bruner, 1988).

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Using the RAW File Format to Enhance Photographic Workflow

by Dr. Eric Weisenmiller, Clemson University

Introduction

In the quest for artistic control and fidelity to original image data, photographers have recently been drawn toward the use of the RAW image file format. This is likely the result of the realization that the customization capabilities of the RAW format extend far beyond those of simple digital capture in JPEG or TIFF format. In effect, RAW capture affords the photographer sole responsibility for the processing of the "digital negative" in such a manner that allows creative and quality control over individual shots after the moment of capture. In addition, the format allows for a certain margin of error during the moment of capture. Differences of opinion can be observed when considering the appropriateness of the use of RAW files, especially when it pertains to the efficiency of their use in a high-volume production workflow. However, the viability of the RAW file format becomes evident when one explores the wealth of custom processing variations, the benefits to image quality, and the potential long-term value of digital assets that can be derived from its implementation within a photographic workflow.

Understanding RAW Files

The RAW image file format could be aptly described as the digital equivalent of a continuous-tone photographic film negative. The obvious differences in their fundamental nature (i.e. digital vs. analog) notwithstanding, the similarities may be difficult to comprehend at first. However, this comparison holds many implications that aid in understanding the digital format if held up in contrast to its analog counterpart.

First, RAW images must be "processed" in order to be viewed or edited in an imaging software application. This scenario is similar to that of film-based photography where images are exposed on film as a response to carefully controlled exposure variables. In turn, the latent image must be processed using traditional physical and chemical means before it is possible to view the recorded image. The intermediate step of processing the film is analogous to the processing necessary to open a RAW image file. In fact, the RAW format introduces an added step in the digital process foreign to many digital photographers who are accustomed to capturing their digital images directly to useable JPEG or TIFF files.

Instead of relying upon the camera itself to process and possibly compress the image data recorded on the sensor to produce a read-ready file, RAW files deliver all of the sensor data pertaining to the luminance values of the image. Software is then used to convert the image data into a useable color image according to a number of user-specified settings. This allows for more artistic and technical freedom as processing power is shifted back to the photographer and away from the camera mechanism. Only shutter speed, aperture, and ISO are controlled at the moment of capture. All other variables are left until the time of conversion (Frasier, 2005).

During conversion, the additional steps available include white balance, colorimetric interpretation, gamma correction, noise reduction, anti-aliasing, and sharpening. All RAW converters perform each of these tasks, but they may have alternative methods of doing so. This is why images may look distinctly different when processed through different RAW converters. Generally speaking, there is no single "correct" interpretation of a given RAW format. Conceivably, the original raw file can be converted (or "processed) any number of times using any number of variations in size, resolution, tonality, color rendition, and so on. All of these iterations stem from the original "digital negative" which remains intact. After conversion, the image is typically saved out as a TIFF or JPEG for printing or other uses.

Understanding Digital RAW Capture

The RAW capture is achieved via a matrix array of sensors contained within the camera (the "digital film"). The image information is directly captured from the camera's Charged Coupled Device (CCD) or Complementary Metal-Oxide Semiconductor (CMOS) without any filters or adjustments applied by the camera. A RAW file is a comprehensive record of the intensity of the light captured and converted to data by the sensor. In other words, the capture extends nothing further than luminance values recorded by the individual sensors of the matrix array irrespective of any color that would be perceptible by human vision. Rather than recording color data at the moment of capture, the sensor merely records the varying

intensities of light in the scene. However, the metadata recorded within the files also records the sequence of the filter pattern used by the specific camera's sensor.

Many different ways exist to encode this raw sensor data into a RAW image file. In each case, the file records the unprocessed sensor data. Nearly all of the digital cameras that shoot RAW are the type known as "mosaic sensor" or "color filter array" cameras. Often this pattern (which is overlaid onto the matrix array of sensors) is known as a Bayer pattern. A Bayer pattern consists of a filter order of "GRGB". That is, the mosaic pattern of photosites that are covered in mosaic pattern by tiny filters are arranged in order of "Green-Red-Green-Blue."

In addition to the grayscale values for each pixel, most RAW formats include a "decoder ring" in metadata that conveys the arrangement of the color filters on the sensor. It tells RAW converters which color each pixel represents. The RAW converter then uses this metadata to convert the grayscale RAW capture into a color image by interpolating the "missing" color information for each pixel from its neighbors. This process is known as demosaicing, and is one of the key roles a converter plays. According to Bruce Fraser, RAW conversion involves several steps in addition to demosaicing (Fraser, 2005). It is during the process of "demosaicing" (that occurs as the RAW interpreting software converts the image) when the pixels are assigned a color value (Fraser, 2005). At this point, custom user intervention is made possible for the interpretation of the image data using an interface rather than letting the camera make the adjustments and conversions immediately after the moment of capture based on camera presets.

In general, what happens when a photograph is taken depends on whether the camera is set to save images as JPEG or as RAW files. If an image is saved in RAW mode, when it is loaded into a RAW conversion program and then saved to a TIFF or PSD file format (as mentioned in the previous paragraph), it can be exported in 16-bit mode. The 12 or 14 bits recorded by the camera are then spread over the full 16-bit workspace. If the image is saved by the camera as a JPEG, it is converted by the camera's software to 8-bit mode that results in only 256 levels per channel with which to work.

When saving RAW files, the camera also creates a header file that contains all of the camera settings. Depending on the type of camera, these settings com-

monly include sharpening level, contrast, saturation, and white balance settings in addition to shutter speed, aperture, and ISO. Therefore, a RAW file is essentially the data that the camera's chip recorded with some additional information tagged on. This additional information is known as metadata. A JPEG file is one that has had the camera apply linear conversion, matrix conversion, white balance, contrast, saturation, and some level of compression that can be destructive to the original image (Luminous, 2004).

It is important to note, however, that each camera uses a unique method to record the camera RAW file information to save image data (Adobe, 2003). Canon, Nikon, Olympus, and the other major camera manufacturers all have slightly differing proprietary methods of encoding image and metadata. Furthermore, each proprietary system has complimentary conversion software with which to process its own RAW files (Fraser, 2005).

The Advantages of the RAW File Format

One of the most pronounced advantages of the RAW file format to the photographer is making use of the superior amount of control that RAW extends beyond the capabilities of JPEG. Since a camera's RAW format is the truest digital negative it can possibly gather, it contains the full range of tone and color information captured by the camera unprocessed and uncompressed. This extends benefits well into the image editing stage where image data loss is imminent. Considering the nature of an image processing or print production workflow, where each step of the process introduces a loss of data (resolution, sharpness, detail, tone, color, and so on), retaining the most information about an image—or at least having control over what information is lost—presents a genuine benefit.

Although the pros and cons of using the RAW format should merit careful consideration prior to implementation, the implications for increased quality and control are obvious. Various reasons to shoot RAW include:

- The photographer has a 16-bit image file (65,536 levels) with which to work. JPEG files only have 8-bit space and 256 brightness levels per channel to work with. This concept is important when editing an image because a surplus of image data is often necessary.

- The photographer gains interpretive power over the image during processing at which time responsive, real-time conversion tools such as Adobe Photoshop CS's Camera RAW plug-in can tweak conversion settings. However, with this power comes the responsibility of learning to master the variables for the expected outcomes or intended use of the image.

- RAW files have not had white balance set. This allows the photographer to set any color temperature and white balance after the fact without ruining the image.

- Processing settings optimized for particular cameras or shooting conditions can be and stored for automated batch processing of large quantities of images.

- Because a RAW file has not been processed in any way, if new and improved methods of image processing come about in the future, archived RAW files can be processed again (Reichman 2003).

- The RAW file is tagged with contrast and saturation information that is set in the camera by the user, but the actual image data has not been changed. The user can set these based on each image, rather than use one or two generalized settings for all images taken.

- RAW files contain two different types of information: the metadata and the pixel information. Metadata contains file information pertaining to the aperture, shutter speed, ISO, focal length, white balance, copyright, rights management, and so on. This information enhances the image by providing information that can be useful to other users of the image while protecting the rights of the creator.

- The RAW file holds exactly what the imaging chip recorded, which means that the photographer is able to extract the maximum possible image quality. This includes all of the color information gathered by the camera. In addition to rendering this color information to sRGB or Adobe RGB color spaces (options also available in JPEG), Adobe Camera RAW can convert the color data to the widest possible color space available for digital capture: Adobe ProPhoto RGB (Fraser 2005).

- RAW file conversion software allows for the creation of profiles customized for specific cameras and/or shooting conditions.

The Advantages of the JPEG File Format

Contrarily, using the JPEG workflow provides much more immediacy, albeit at the expense of quality and all-important artistic control. Some reasons to shoot JPEG include:

- Smaller file size allowing more images to be packed onto a storage card. RAW files are double, triple, or quadruple the size of JPEGs.

- Whereas RAW files take time to record on camera and time to process during post-exposure conversion, JPEGs offer visual and practical immediacy.

- Often, the quality of the JPEG file is appropriate for the intended end use of the image; using an industrial-strength RAW file with extensive production techniques may be overkill resulting in a waste of time and money.

- For journalistic purposes, where quality is secondary to timeliness, and when small files are easier to transmit electronically.

- Many photographers do not have the time or even want to post-process their files; many cameras are not able to shoot quickly when working in RAW mode and some lower-end models cannot record RAW files at all (Reichman, 2003).

- Sharpness, contrast, resolution settings must be made on the fly when shooting image-by-image if necessary. Although destructive to the image, applications such as Adobe Photoshop are able to enhance detail or correct tonality.

Managing Your Digital Camera's RAW Files

Using software such as Adobe Photoshop CS, it is possible to order, flag, and add keywords to each image. This adds to the additional embedded metadata alongside the image file that already contains information pertaining to the time of capture, f/stop, shutter speed, type of camera, ISO, focal length of the lens, copyright, rights usage, and so on. Ordering and flagging files not only streamlines workflow, but also adds value to the digital asset as well as copyright protection. Preserving these versions of photos

in an image archive complete with metadata is important. However, many image browsers are designed to support only the photo formats they understand and contain only the necessary code to decompress a JPEG photo since they mainly support the JPEG format. Chances are, however, that they will not understand a RAW file. If you want to open a RAW file in Photoshop to give to a client or put on the web, it has to be converted into a standard format such as JPEG or TIFF. A new version of the photo is created in the selected format while the original RAW photo remains intact—perhaps for use as an archive copy.

Automated features of Adobe Photoshop CS allow for automation and batch processing of images. Settings to produce contact sheets, picture packages, and web galleries can easily be set-up using preset or custom settings within Adobe Photoshop's automated functions. This automation allows the user to streamline the production flow after presets are created to suit a particular range of purposes. Applying these functions with applicable presets can set the computer in motion to process images to specifications automatically without the need for an operator.

Processing RAW digital images one-by-one offers no real time savings that would outweigh the use of film for the same purpose. However, if images are processed using a streamlined process using the RAW format in conjunction with the Abobe Photoshop CS File Browser feature and Actions commands, numerous files can be processed in succession in an automated fashion. Once the RAW conversion settings have been carefully adjusted and set by the photographer, they can be saved and, in turn, applied to all incoming images automatically; the computer does the processing of each image based upon the critical thinking skills set forth by the photographer. Based upon the knowledge of tone, contrast, exposure, and color determined by the artistic professional, the computer carries out the time-effective instructions on each incoming image. This is not done by adjusting the image in Photoshop, but by controlling the conversion prior to its appearance in Photoshop. Consequently, the amount of work that is required in Photoshop is reduced. While Photoshop Camera RAW offers much faster conversions than a camera's native software, its batch processing is limited to applying the same settings to every image (Fraser, 2003).

Adobe's DNG Initiative

In late 2004, Adobe Corporation announced plans to initiate standardization of camera RAW file formats produced by the various digital camera manufacturers (Digital Photography Review, 2004). Since the DNG standard will be publicly documented, DNG files boast the ability to be self-contained. That is, non-proprietary camera file format specifications used for RAW conversions will be established. This is an effort to alleviate the need for periodic software updates in order to retain the ability to process various conversion algorithms specific to each manufacturer's camera equipment. The DNG standard permits the addition of manufacturer's proprietary metadata to be tagged onto the file.

As DNG holds the promise of creating a generally accepted archival format that poses no danger of being abandoned in the near future, users of the RAW format can continue to archive RAW files secure in the knowledge that their images will be accessible for the foreseeable future (Adobe Systems Incorporated, 2004).

Conclusion

The capture of photographic images by digital means has stirred a revolution in the photographic and digital imaging realm. The impact of digital photography can be observed from top to bottom—from high-end professional to novice user. However, as the old adage goes: the more things change, the more they remain the same. Such is the case with the state of photography. Just as changes in technology arise, the constants of control and knowledge of those controls become more vital to the skill set required for those who desire complete artistic and technical command of their images. Advances in digital photography, as well as the continued development of technologies for digital image post-production, are unleashing new possibilities for digital image workflows. According to Microsoft, "it's a JPEG world" (Microsoft, 2004). However, the RAW format is gaining in popularity among "quality-minded" digital photographers, but as of yet the format is not as universally supported as JPEG. Although each camera manufacturer has heretofore developed unique RAW format algorithms, RAW-friendlier workflow options are foreseeable due to the increasing awareness of the potential versatility that the RAW format offers. At this point in time, managing RAW photos efficiently and effectively can be tough without careful planning, so close examination of specific workflows is vital to wise usage of RAW files.

Much like the evolution and acceptance of Adobe's Portable Document Format (PDF) throughout 1990's,

the acceptance of RAW files as a viable option to photographers will depend upon industry inroads, standardization, and education of photographic and prepress professionals. The capabilities of artistic control coupled with its inherent processing controls make the RAW file format the next logical step in the progression of digital photography as it interfaces with the photographic and print production workflows. As prices drop, making higher-end cameras more accessible for the prosumer and consumer markets, the RAW file format will be made increasingly available. It is not a stretch to conjecture the growing use of this file format as it extends farther down into the hands of not only professionals, but also the hobbyists or photographic enthusiasts. Toward this end, understanding of the file format is key to unlocking its full potential.

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Curricular Components of Database Technology for Graphic Communications

by Dr. Daniel G. Wilson & Dr. Klaus Schmidt, Illinois State University

Introduction

The shift toward automation in print production and procurement is creating a greater need for database management knowledge among graphic communications graduates. It is becoming common in cutting-edge commercial printing facilities for production personnel, management personnel, and customers to organize, search, and route document files over local and wide area networks in real time. The management of digital data in the form of native application files, PDFs, ColorSync files, font files, image files, and web graphics through software solutions and networked servers has not only become a revenue source for printing companies, but is an essential requirement for automated quotes, file transfer and preflight, automated print production, variable data printing, and management information systems (MIS).

Because of these trends, graphic communications educators may need to address more database technology in their curricula. It is the position of the authors that students of graphic communications should have a theoretical and practical knowledge of object and relational databases as they apply to multimedia and imaging databases in order to be able to better conceptualize modern workflows. Fundamental database curricular components that will be considered here include tables, relationships, join types, data types, and queries.

Rationale of the Curricular Problem

The commercial printing industry is changing in truly profound ways. The internet, file exchange, and database technologies are playing a key role in automating customer interfaces, allowing customers to submit job specifications for quotes on-line, and providing management of digital assets (such as images and document files) with full access and control from the web portal. The development of more sophisticated servers, databases, and networking technology is allowing for the control and monitoring of job specification gathering, job quotes, job content, order entry, job planning, and electronic proof distribution and approval. Software solutions in Heidelberg's Prinect family and Creo's UpFront, Brisque Serve, and Timna are examples that provide commercial printers with some of the necessary tools.

Variable data printing has begun to mature as well. Examples include software solutions that work with QuarkXPress—like Creo's Darwin Pro and Quark's QuarkXClusive—to provide an interface between a targeted picture box in the layout and a properly configured database of content. This enables variable data to be RIPed and printed to digital presses. Configuring and maintaining databases is fundamental to these operations.

Content management, also called digital asset management, has become a revenue stream for many graphic communications businesses. Digital assets are files used in document creation and reproduction (whether print or web media), including text, fonts, graphics, photos, layouts, as well as other file types such as video clips and audio files. Content management can be defined as the organization of digital media files to enable authorized individuals to find, retrieve, and route an item to a designated person or into an automated work process, generally through a web portal (Seybold Report, 2003). Simply put, content management allows customers of print and web media to store, organize, retrieve, and use all of their digital assets without having to archive or organize them at their own site.

Curricular Components of Databases

Central to many emerging graphic communications technologies is database technology. But how do we teach fundamental concepts about database technology at a level that is appropriate for graphic communications students? What are the key curricular components that students need to acquire to help them function in tomorrows automated workflows? Students can benefit from course content that includes an exploration of relational database management systems (RDBMS). There are a variety of sources for RDBMS content written at a level that is appropriate for graphic communication educators to further their knowledge and for use in the classroom. (Date, 2004; Elmasri & Navathe, 2003). The most salient concepts are described in the following paragraphs.

The Underlying Structure of Content Management

RDBMS are capable of accommodating huge amounts of digital data in a very efficient way. The data can be stored and retrieved in various ways. Unlike older flat database structures, where all data is stored in one large table causing redundancy, data is split into tables that are linked to one another through relationships. In this way, RDBMS are the underlying structure of content management systems used in the graphic communications industry. Content management systems are generally divided into two parts: the media catalog and the data farm/asset repository (Ross, 1999). Media catalogs are databases that allow users of the system to search for files through the use of items such as thumbnails and keywords and provide information about the files such as captions, resolutions, and/or file sizes. Asset repositories, also called data farms, contain the actual content of the system. The files stored in the repositories are generally divided into two groups, content files and object files. Content files are text, page layout, and vector graphic files, and object files include bitmap images and PDF documents or other metafiles (NAPL, 1998). Using these two groups, users search through a graphical user interface, such as a website or other local browser, and access the desired digital asset stored on a server.

Basic Elements of RDBMS

To conceptualize RDBMS, basic database terminology must be understood, including tables, records, and fields. A record is defined as all information pertaining to one specific item, such as a customer, image, the specifications of a print job, or a production center within the business. For example, all information stored for a specific customer is considered a record. The record is broken down into various fields. In this case, field names might include Name of Business, Last Name, First Name, Phone Number, and Street Address. A table contains columns and rows, much like a spreadsheet, with rows indicating a record, and columns a characteristic of that record.

The most efficient way to store data is to break the information into logical groups of data. For example, a printing company may have employees, customers, material, products, and services. All information pertaining to employees, such as name and social security number, belong in one table. All information pertaining to customers, such as shipping address, phone, business, and

tax ID number, goes into another table. Information about the paper grades kept in stock is stored in a third table, and so forth.

It is important to understand that a piece of data only needs to be stored once within an RDBMS, making replication of the same data somewhere else in the database unnecessary. Once one piece of information has been entered in a table somewhere in the system, it can be retrieved and displayed along with information from any other table that has a direct or indirectly established relationship with other tables in the same system.

The next important database concept is how the data should be stored in terms of data types, field properties, and constraints. There are many data types just as there are a large number of database platforms. However, some data types are common throughout various platforms including integer, decimal, currency, float, data/time, character, text, binary, and image. The names of data types may vary across platforms.

Database Relationships

Once the data types have been defined, the learner should study how various tables can be related. In order to enable a relationship between tables, both tables must contain one identical field, as the basis of the relationship. For example, both a customer table and a sales table would need to have an identical field, like a customer ID field, in order to create a relationship. There are basically three types of relationships. A "one-to-one" relationship exists when a record from one table can have only one related record in a related table. For example, a customer ID in a customer table may be related to only that customer's tax ID number in the billing table.

A "one-to-many" relationship exists when a record from one table can have multiple related records in a related table. For example, suppose that a graphics company manages all of John Smith's digital image files. The customer table would contain all of the information pertaining to John Smith (i.e. customer ID, street address, and e-mail). An image table, containing many different images, would be related to this one customer. The image table might contain fields such as customer ID, image name, file format, and color mode.

The third type of relationship is the "many-to-many" relationship. This relationship requires an intermediate

table to establish a functional relationship between two tables. For example, a table of a company's paper inventory (containing records of hundreds of paper items) might be related to the sales table (containing records of perhaps hundreds of customers). One particular customer in the sales table might commonly use five different stock items. However, multiple customers might use each of those stock items. In a many-to-many scenario, an intermediate table might be generated to record the sales of paper items by each customer.

Database Join Types

In addition to understanding relationships, it will be important for students of graphic communications to understand how the tables are joined. There are two basic join types, including "inner join" and "outer join." The join types are of highest importance when querying the database. When querying two tables using an inner join, the only records returned would be those that have shared information in both tables. However, assume that John Smith is in the customer table but currently has no images in the images table. When querying for anything based on these two tables, an inner join would return no information pertaining to John Smith.

In order to also see customers that might not have images currently archived, an outer join would have to be used. This would return all customers with the potential to have images in the table (including John Smith, even though he has no images stored at the present time). There is also a distinction between a left outer join and a right outer join. The previously described example is a left outer join. A right outer join would be used if we had images in our image table that were not related to any customer, and we wished to have them displayed/returned with a query.

Database Schema

The concepts and terms previously discussed are central to understanding how a database schema can be developed. The schema gives a good oversight of all data in the database. In other words, when designing a schema, the overall relationships, join types, tables, and fields names are graphically displayed for planning of the RDBMS. The schema can be viewed or printed for review using functions within the database platform.

Database Queries

In addition to understanding how to store data, students will need to conceptualize how data is retrieved from databases using queries. There are two major types of queries including "select queries" and "action queries." Select queries are used to retrieve data from one or more tables for display in a certain way. For example, all information pertaining to the customer of a printing company may be contained in a table. However, one employee's task might be to call each individual customer on the phone for a new marketing initiative. A select query could be run that only selects customer names and phone numbers from the table. All other information pertaining to the customer is irrelevant for this particular task and will not be displayed.

RDBMS also allow parameters to be applied to a query. For example, the employee can request a phone list of only the customers from the State of Illinois. The database administrator then retrieves information from the customers table using a parameter that limits the selection of customers to the S tate of Illinois.

Action queries, unlike select queries, do not retrieve information from the tables. Rather, they make changes to the table and modify the original data. These can be particularly powerful in production situations. For example, an action query might be made to change the resolution of images within an images table. Another example might be a delete query, an update query, and an append query.

Database Applications

A full theoretical understanding and working knowledge of databases involves more than has been here described. However, the ability to conceptualize tables, fields, data types, join types, queries, and relationships should be considered curricular fundamentals for relational database management systems. Developing lab activities around these concepts would require appropriate software applications. Some common open-source RDBMS platforms include Oracle, Windows SQL Server, DB2, and UNIX/Linux MySQL. Systems that may be affordable in a lab setting include Windows SQL server, MySQL, and dBase.

Discussion and Summary

Commercial printing companies are integrating marketing, sales, management, and production functions with computer solutions. Computer Integrated Manufacturing (CIM) is becoming a reality in an industry long known to be highly manual. In cutting-edge facilities today, customers can enter specifications online, receive a quote, transmit document files, and check on job status all through a web browser. Jobs can be planned and initiated through shared, networked databases of content. With the growth of the Job Definition Format (JDF), a standard for data exchange among networked and automated production equipment, job specifications can be electronically routed through the workflow.

Today, educators of graphic communications are charged with integrating content on traditional processes with information technology. Educators have long been aware that teaching "everything" about the industry is quite impossible. However, the goal of vocationally oriented graphic communications educators has always been to impart fundamental knowledge that will enable graduates to quickly learn and function in a host of varied graphic communications firms.

This research provides an overview of curricular components of database technology that the authors deem fundamental to today's graphic communications graduates. In additional to this exposure, students may also require some level of knowledge of computer networks, Internet technology, and telephony, all of which are closely related to this content. Based on current technological trends, these topics may need to be further explored and reassessed in terms of what is "fundamental" to the success of the graphic communications graduate today.

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Identifying High-Volume Printing Processes

by Dr. Malcolm G. Keif & Tom Goglio

Printing professionals frequently examine printing to see how pieces were produced. They break out loupes and look at the dots. Is it offset or gravure? How about flexo? It is important to be able to distinguish among printing processes through examination in order to determine the key variables to control for quality printing. Further, expertise is established and confidence built when a professional can determine how something is printed.

When examining a printed sample to determine how it was printed, one must look with a critical eye and consider several factors. Considerations include the use of the product, the substrate, the expected run length (including versioning), print quality, characteristics of type and line work, and the characteristics of halftones. It is usually easy to determine a product's printing process. However, printing and prepress technologies have seen rapid improvement in recent years, making it more difficult to distinguish one process from another. Many inherent characteristics used to differentiate printing methods in the past are no longer clear determinants. High-volume printing processes are beginning to attain near-perfect line or tone reproduction, particularly when laser imaged printing plates and cylinders are used. This makes identification more challenging.

Identification is also complicated by the increased use of combination printing processes. For example, in flexible packaging, flexo presses often incorporate in-line rotary screen printing. A screen unit lays down opaque white ink upon which process inks are printed using flexo plates—allowing graphics for frozen food bags on clear film. Also common are flexo units at the end of rotogravure retail insert presses for regional versioning. Combination presses are frequently used in the gaming industry, where lottery tickets may use three or more printing processes including flexo, gravure, screen, and digital printing on a single ticket.

Despite the challenges, the astute viewer can usually identify a product's primary printing techniques with a standard 10X loupe or magnifier. This paper focuses on distinctions between three high-volume printing applications: Web Offset, Rotogravure, and Flexography. After reading this paper, the reader will know more about the characteristics of each process and can confidently identify a process through investigation. This paper does not address low-volume processes such as sheetfed offset and digital printing processes.

When individuals examine printing, they should consider the following questions: Does a product's use give any logical hints? Does the type of substrate lend itself to being printed by any one particular process? What is the expected run-length of the product? Does the quality of the printing point to a particular process? Finally, do the type, line-work, and halftones exhibit any revealing characteristics? The characteristics of web offset printing will be covered first. See Table 1.

Web Products	Typical Printing Process(es)		
	Offset	**Gravure**	**Flexography**
Commercial Printing	✓		
Magazines	✓	✓	
Catalogs	✓	✓	
Books	✓		
Business Forms	✓		
Envelopes	✓		✓
Newspapers	✓		✓

Table 1 – Common printing processes used for high-volume products (continued on page 35)

Web Products	Typical Printing Process(es)		
	Offset	**Gravure**	**Flexography**
Flexible Packaging		✓	✓
Folding Cartons	✓	✓	✓
Corrugated Postprint			✓
Corrugated Preprint	✓		✓
Tag and Label (excluding sheetfed)		✓	✓
Giftwrap and continuous-image products		✓	✓

Table 1 – Common printing processes used for high-volume products (continued from page 36)

Web Offset

Web offset is a printing process typically utilizing two printing fluids (ink and fountain solution) and a flat aluminum plate. The ink is transferred via a rubber (or elastomeric) blanket to the substrate. Web offset is popular in many markets and, along with its sheetfed cousin, accounts for about 50% of all printing in the United States.

Uses of Web Offset

Web offset is used for numerous commercial products such as flyers, brochures, general advertisement, business forms, direct mail, publications and catalogs, books, newspapers, and folding cartons. Some of these market segments utilize competing processes—particularly publications and catalogs (gravure), newspapers (flexo), and folding cartons (gravure and flexo).

Substrates

Web offset typically prints on paper with average to high smoothness. Typical papers for publications include 40–100 pound coated and uncoated book papers. Folding cartons use paperboard typically thicker than .018 inches. Web offset does not print well on plastic sheets, films, or foils. Therefore, web offset may be ruled out for most flexible packaging applications. Further, web offset is not typically used for corrugated carton printing. Sometimes, however, a preprinted litho sheet may be laminated to a corrugated medium.

Expected Run Length

Web offset is economical for run lengths as low as 10,000, or into the millions. Web offset may compete with sheetfed offset for short runs and with gravure for long runs, depending on the product. Offset offers easy and inexpensive plate changes, making it well-suited for versioning. Some long-run magazines have offset covers and advertising sections with gravure editorial pages. Examples include *National Geographic* and *Good Housekeeping*. Be careful to examine both advertising and editorial sections before drawing conclusions.

Quality of the Printing

Due to its high quality and image richness, it is sometimes difficult to differentiate offset litho from gravure or flexo. Historically, ink/water imbalance, resulting in color variation throughout a press run, has been the enemy of the offset printer. As more closed-loop color controls have been installed on web presses, ink variation has decreased, offering consistency that rivals gravure. However, if color does vary across a run or even across a spread, it may be web offset.

Web offset produces a broad tonal range and is often superior in its highlight and shadow detail. Gradations generally look very smooth even in extreme highlights (0–10%). Vignettes show no drop-off and images can be produced near photographic quality.

Offset news inks dry incompletely (by absorption) and darken one's hands as a newspaper is handled. In contrast, flexo newspapers use ink with through drying agents. So, offset printing may be suspected if ink rubs off a newspaper onto one's hands or discolors skin (see Photo 1).

Type and Line Work

Web offset offers relatively smooth type and line work. Under high magnification (50X), you will see some raggedness on the edges. This is usually a result of the
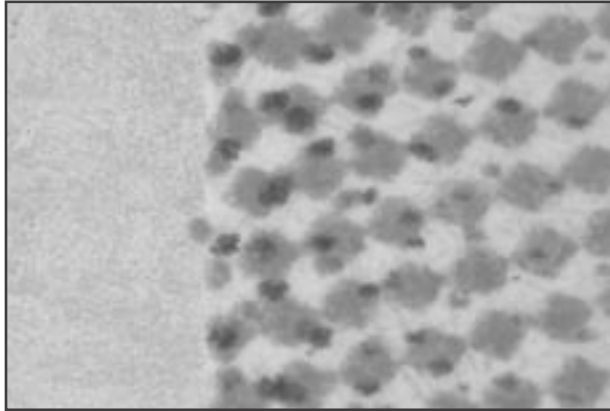
Photo 1 – This offset printed magazine shows relatively consistent halftone images and a smooth gradation in the black.
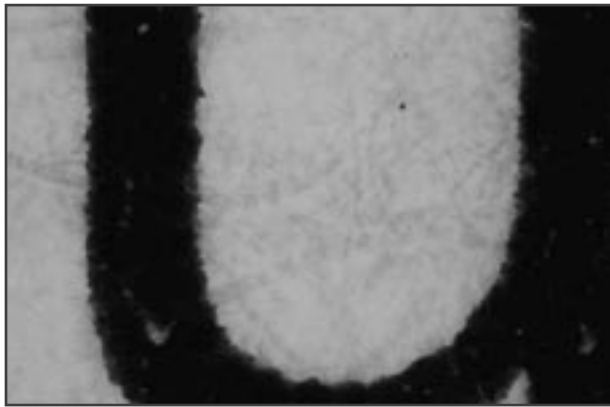

Photo 2 – Relatively smooth edges on the type and no halos leads to identifying this as offset lithographic printing.
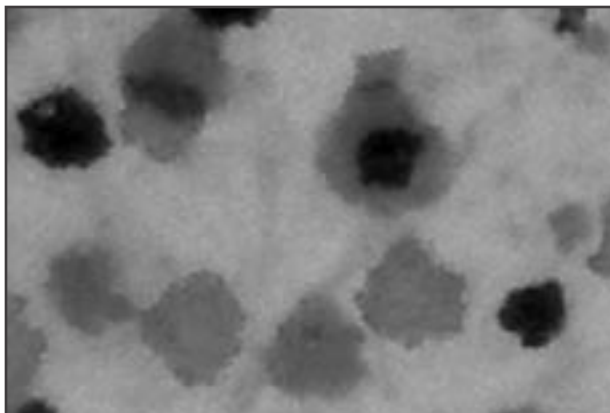

Photo 3 – These litho dots show good uniformity and no doughnuts. The inconsistent shapes are likely a result of substrate absorption.

substrate roughness in combination with the grain of the litho plate. These ragged edges should not to be confused with gravure printing, where the "jaggies" (resulting from the engraved cells) are quite visible. See the gravure section for samples of gravure type (see Photo 2).

Halftones

Web offset halftone dots may exhibit ragged edges under high magnification. Litho dots are not typically uniform, though the imaging technology can impact the shape of the dot. Computer-to-plate (CTP) devices will often produce sharper and more uniform formation than traditional platemaking methods. The grain structure of the actual plate may further impact the dot uniformity. In addition, paper surface will have a significant effect on dot roughness. Coated stocks result in better ink holdout and provide a more uniform dot shape than uncoated papers (see Photo 3).

Although some recent work has been done in both flexo and gravure using frequency modulated (FM or stochastic) screening, this is usually an indication of lithography. Hybrid screening (a combination of amplitude modulated (AM) and FM screening) is more common in flexographic printing, where the unique benefits of FM screening for highlights and shadows can be incorporated with the smooth rendition of traditional screening in the quarter-tone through three-quarter tone areas.

Gravure

Like offset, gravure is a high quality printing system. It utilizes an engraved cylinder with a recessed (intaglio) image area. Everything to be printed is engraved into the cylinder—halftones, line work, and type. This is an important feature in the identification of gravure. While there are specialty engraving processes that may not have jagged type, a typical characteristic of gravure printing is the serrated edges around type. Gravure accounts for about 16% of all printing revenues in the United States.

Uses of Gravure

Gravure is used for a number of different products including long-run publications, catalogs, retail inserts, folding cartons, and flexible packaging. In addition, gravure is often used for many continuous-image products like gift wrap, vinyl floor covering, and wallpaper, where there is no defined beginning or end to the image.

As mentioned earlier, gravure has competition in many product segments—namely publications (offset), folding cartons (offset and flexo), flexible packaging (flexo), and specialty products (offset, flexo, and even screen printing).

Continuous-image products are usually printed gravure, as the cylinder can be easily engraved with a seamless repeating pattern (in some cases flexo can also be used for continuous-image products). Many simulated wood grains are produced in this manner taking advantage of the seamless repeated pattern. Offset is usually incapable of producing continuous-image products.

Substrates

Gravure prints well on paper, films, and foils, as well as laminated materials. In general, gravure requires smoother substrates than either offset or flexography. If the substrate is highly textured, it is not likely to be printed by gravure (although some gravure products may be embossed or textured as a separate finishing process). The substrate's surface must contact each and every gravure cell for complete ink transfer. For this reason, paper and paperboard are frequently coated or calendared for gravure printing. While flexo and litho easily print on rough surfaces, the substrate must be smooth for gravure. Publication gravure also frequently prints on much thinner papers than litho. This is another tell-tale indicator of process.

Expected Run Length

Gravure is known for being most cost-effective at long run lengths or for repeat work. Although much is being done to reduce cylinder costs—with an eye toward shorter runs—gravure cylinders are still more expensive than offset or flexographic plates. This fixed-cost must be offset by one of gravure printing's many strengths—low variable costs, rich shadow detail, consistency, continuous-image printing, and variable repeat. Gravure packaging printers occasionally print 50,000 pieces or less, but typically print much higher quantities or produce multiple short repeat runs from the same cylinder. Since packaging graphics don't change as frequently as magazines, they can be printed, stored, and rerun many times.

Publication gravure printers prefer run-lengths over 1/2 million impressions. Gravure magazines often have covers and regional or targeted advertising sections that are printed via web offset. Circulation is one determining factor of whether a magazine is a candidate for gravure.

Photo 4 – Two gravure printed catalogs.

Runs under 500,000 are usually offset, while runs over one million are often printed by gravure. Publications requiring runs between 500,000 and one million can be printed by either offset or gravure. Of course, time-compression may play a role—most weeklies are printed web offset regardless of circulation (see Photo 5).

Quality of the Printing

Gravure printing has long been considered the Cadillac printing process. Its hallmarks are its very high-quality, rich vibrant colors, and great shadow detail. This is particularly true of photographs and other tonal work. Gravure's ability to lay down a thick three-dimensional ink film—altering not only the width of the dot but also the depth—produces brilliant color (see Photo 6).

This is easily noticeable when looking at black ink areas. Gravure can usually produce a richer black than other processes. For example, a noticeable distinction will be apparent in the black-ink areas of a foreign language edition of a *National Geographic* magazine compared to the same edition circulated in the U.S. Since U.S. editions of *National Geographic* are printed with gravure, and most foreign editions are produced using web offset, the U.S. version will have darker richer blacks because gravure lays a dense thick film on the substrate.

Type and Line Work

While gravure excels in image quality, many criticize its inferior type and rendition of line work. Gravure printing is usually characterized by its serrated edges on type and line work. This serration is due to electromechanical cylinder engraving methods that screen not only tones, but also type. Under magnification, this is quite
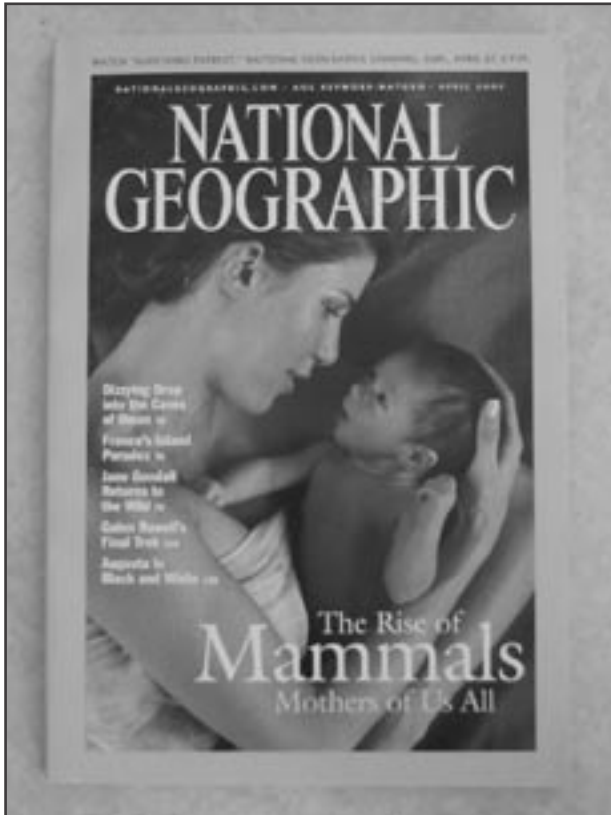
Photo 5 – The US edition of National Geographic magazine has a web offset cover and some advertisements, and gravure editorial sections. An interesting comparison is to acquire a foreign language version to compare with the US version. Foreign language versions are mostly offset.

noticeable. Care should be taken, however, to not confuse a process screen mix with gravure's serrated edges. Examine solid black type rather than a screen build or reverse, which can be misleading.
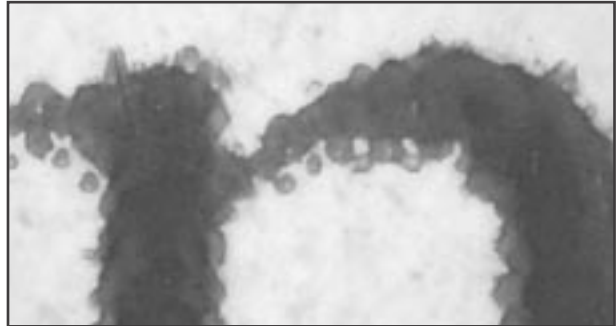

Photo 7 - The serrated edges around the type are a sure sign that this is a gravure printed product.

Recent advances in cylinder engraving technologies have seen dramatic improvements in type and line reproduction. Direct laser engraving, as well as other new technologies (such as Xtreme engraving or Transcribe), minimize serrated type.

Halftones

As previously noted, gravure printing involves pulling ink out of recessed cells. The most common shape of these miniature cells resembles an inverted pyramid. The tip of the pyramid (the bottom of the cell), does not readily release ink. This, in combination with the ink's surface tension, often results in non-uniform ink coverage. The resulting dot often resembles a "doughnut." Flexo printing also exhibits hollow-centered doughnut tones.

The release of ink from these problem areas is aided by an electrostatic charge, known as electrostatic assist
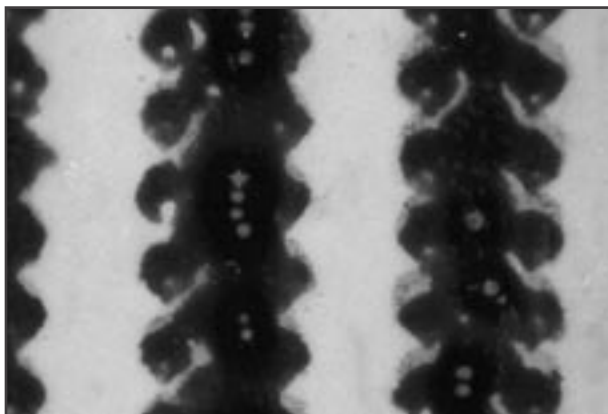

Photo 6 – This barcode from a beverage carton shows the variable ink-film thickness capable of gravure printing.

Photo 8 – These tones show the doughnut center typical of gravure printing. This sample used laser engraved cylinders.

(ESA). This process incorporates a static charge at the cylinder nip, attracting the ink to the substrate. However, this often results in a residual static charge in the substrate. Open a magazine or catalog and if you notice significant static, it is quite likely a gravure product.

While the predominant process of gravure engraving is electro-mechanical via a diamond stylus, laser engraving technologies have seen limited market penetration. Laser engraved dots exhibit slightly different print characteristics. The cell shape resembles a round-bottom cup rather than the inverted pyramid. The resulting ink release characteristics are quite different and the doughnut pattern is reduced.

Flexography

Flexography is a printing process using a raised polymer or elastomeric plate to transfer ink to a substrate. It has historically been a lower quality process than either offset or gravure. However, over the last decade, flexo print characteristics have improved so that it is now a high-quality process. This increase in quality is related to research and development in anilox rolls, plate technology, and inks. Computer-to-plate flexo is now common and energy curable ink technology in narrow-web applications is quite advanced. Flexography accounts for approximately 20% of the US printing market.

Uses of Flexo

Flexography is used for a number of different products, but is dominant in the packaging arena. Flexography can print on a number of different substrates, including very rough surfaces. Flexo products include folding cartons, flexible packaging, corrugated cartons, shrink sleeves, and pressure sensitive labels. Flexo is also used on a limited basis in the newspaper industry. Flexo competes against other printing process in some of these niches—namely folding cartons (gravure and offset), flexible packaging (gravure), and newspapers (offset). Additionally, pressure-sensitive labels receive competition from the sheetfed glue-applied technologies and, to a lesser degree, gravure and intermittent web offset presses. While continuous-image jobs can be printed by flexography, they are more commonly printed by rotogravure (see Photo 9).

Substrates

Flexography is one of the most versatile processes when it comes to substrate selection. Flexo prints on films, oils, paper, paperboard, and other materials. Because of its resilience, the flexo plate compresses and fills voids in the substrate surface, allowing it to print on both smooth and rough substrates. That is why the majority of corrugated boxes are printed by flexography. The rougher the substrate, the more likely it is printed by flexography. Screen printing is also excellent at rough substrates but is used for only limited high-volume applications.

Expected Run Length

Like offset, flexography prints both short-run and long-run jobs. Plate life is quite long and, like gravure, flexo plates are often cleaned and saved for future work. However, flexo plates usually last less than one million impressions. Therefore, plate changes are required for run lengths over one million impressions (see Table 2).

Quality of the Printing

In years past, flexo was easily identifiable due to inferior print quality. Historically, flexo was noticeable with the naked eye, possessing a strong "halo" pattern where the ink was squeezed at the edges of the print. This characteristic may still be noticeable under magnification. However, flexo has improved. Presses and press operators are more sophisticated in applying impression, "kissing" the plate to the substrate. So, quality no longer easily distinguishes flexo from other processes.

Vignettes are still challenging in flexo. There is commonly a drop-off near the highlight area of the gradation. Somewhere around 10% (the actual percent varies), the gradation will simply drop-off, resulting in a dramatic loss of highlight detail.
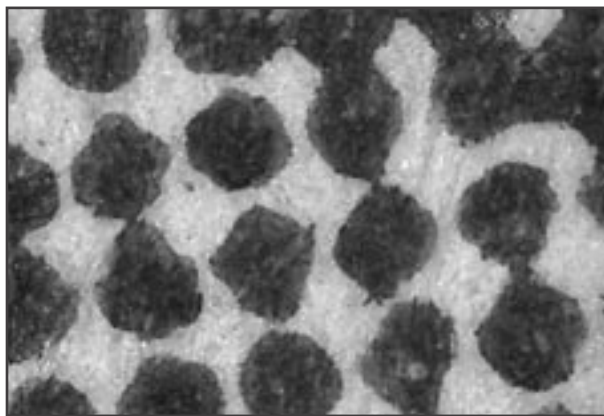

Photo 9 – This flexo newspaper shows very slight doughnuts in the halftones. The ink will not rub off as easily as an offset newspaper.
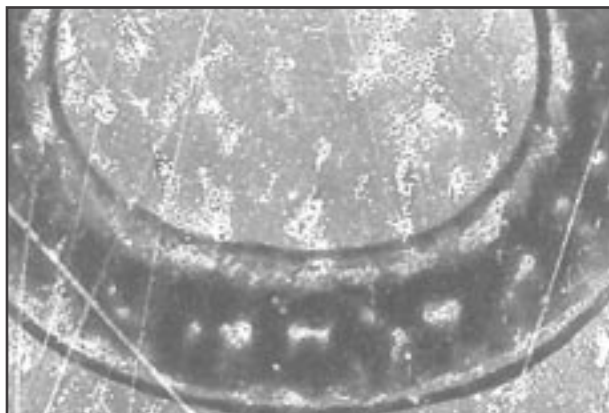
	Web offset	**Gravure**	**Flexography**
Substrates	Paper or paperboard only	Smooth substrates only – paper, film, or foil	Most substrates including very rough substrates
Run-length	Short-runs and long-runs possible. Plate changes may be required	Most economical for long-runs or repeat jobs	Short-runs and long-runs possible. Plates last longer than offset but not as long as gravure cylinders.
Quality characteristics	Color inconsistency over long run or spreads may be apparent. Good highlights and gradations.	Rich blacks and deep colors. Thicker ink film gives more vibrant color. May be weak in highlights and gradations.	Often quality expectations are lower for flexo. Weak highlights and drop-off in gradations. Registration may be inferior.
Type and line work	Few noticeable defects.	Serrated edges on type unless advanced engraving technique used.	Halo around type, particularly on films and foils.
Halftones	Few noticeable defects. Generally fairly smooth.	Noticeable doughnut effect on non-absorbent stocks	Noticeable doughnut effect on non-absorbent stocks.

Table 2 – Common characteristics of high-volume print processes

Because flexo plates are usually mounted without pin-registration, there may be slight register issues. Although registration techniques are improving, flexography is most likely to have looser registration tolerances.

Type and Line Work

As mentioned previously, under close examination, a "halo" effect may be seen on type and line work produced using flexographic printing. Factors that have contributed to the diminishing of this effect include harder durometer plates and more precise pressure controls on press (see Photo 10).

Halftones

Flexo halftones resemble gravure halftones. Hollow-centered (doughnut) dots are a result of non-uniformed ink distribution on the plate surface, in part due to the surface energy of the plates. Plate capping or advanced screening technologies may improve this characteristic (see Photo 11).

The edges of flexo halftones may not be uniform. Unless laser imaged, flexo plates will likely exhibit significant variation among the dots. Highlights, in particular, may suffer in flexo. As a rule of thumb, if there are no tones smaller than 10%, the job may have been printed using flexo.
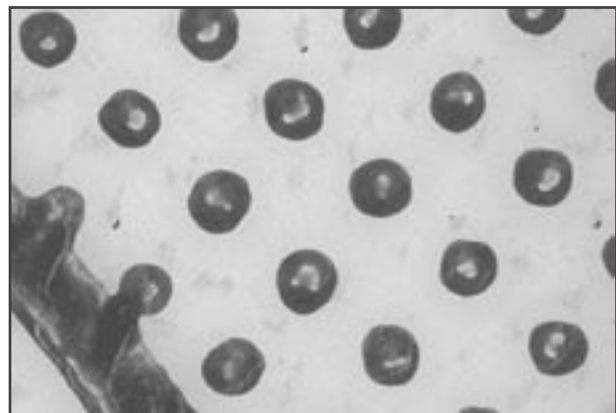

Photo 10 - This letter "O" printed on foil shows a very distinguishable halo around the edges, a clear sign of flexography.

Photo 11 - The doughnut tones, combined with the halo on the type makes one suspect this is a flexo sample.

Combination Printing

Combination printing is gaining in popularity to take advantage of the benefits of different processes. It also significantly complicates the diagnostic process of identifying printing processes because the characteristics of more than one process are inherent in any given sheet. One common application of combination presses involves the use of screen printing units to lay down a thick, opaque white layer on clear film before flexo or gravure printing is applied. Combination printing can also be used to "version" a high-volume print job. For example, the name and address of a local retailer can be imprinted onto a high-volume advertisement printed by offset, gravure, or flexo. Versioning units, which may be flexo, offset, or digital, may be incorporated into any high volume printing press.

Conclusion

While identifying high-volume printing process can be very challenging, with careful examination and logical deduction, one can usually come up with a good guess on which primary printing method was used. Begin by considering the use of the product. Next, examine the substrate and expected run-length of the product. Finally, examine the overall quality of the product as well as the specific appearance of the type, line work, and halftones. These steps make identifying high-volume printing processes easy.

Biographical Information

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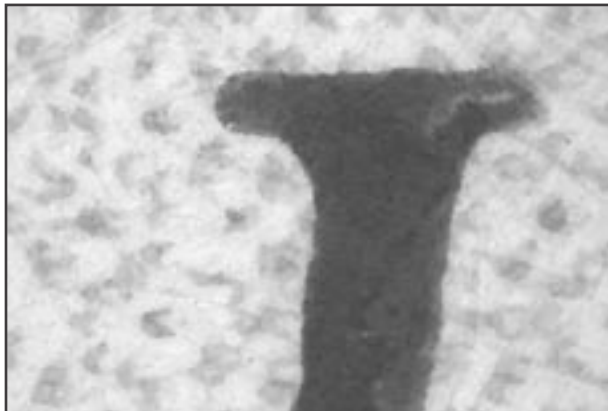

Photo 12 – This Sunday Magazine is printed gravure but uses flexo to imprint the newspaper's name on the front.

Teaching Students about White Balance and Color Correction using Digital Photography

by Dr. Jerry J. Waite, Dr. Cheryl Willis, and Garth Oliver, University of Houston

Editor's Note: To view the photos in color go to:
http://www.igaea.org/Images/Waite/

Introduction

Today's consumer expects good color reproductions. Yellow people, green skies, and blue foliage are not acceptable in today's color-charged world. Southworth and Leyda (1998) describe some of the factors that cause a color reproduction to be "good" in the eyes of the beholder as the following:

• The contrast must be correct.

• The color hues must be accurate.

• Memory colors must be accurate.

• The color balance must look natural.

• Gray balance should be accurate and look normal.

"Good" reproductions are dependent upon the light source used to illuminate the subject, the film or digital camera settings, the calibration of the computer, scanner, and monitor, skillful use of image editing software, and appropriate color separation processes. If the light used to illuminate the original scene is not white, the colors in the photographic image will be skewed toward the predominant color produced by the light source. Such photographs are incorrectly white balanced and all the colors in the image will be off balance.

The impact of the light source on a color image has traditionally been difficult to explain to graphic communications students because film had to be developed before feedback could be obtained. However, the advent of the digital camera now makes it possible to not only photographically capture correct colors but to also purposefully capture incorrect colors. In addition, feedback to students is almost immediate. Since the quality and accuracy of the original photograph affect all subsequent processes, this paper will describe a demonstration activity that teaches students the why and how of capturing images that closely approximate the original scene, the importance of calibrating their monitors, and the use of image editing software to correct images that have been incorrectly captured.

In addition to explaining the technology involved in capturing correctly white-balanced color images and subsequent adjustments that must be made, setting up a demonstration in which illuminant and camera settings result in both correctly and incorrectly white-balanced reproductions will help students to understand the impact of light on a reproduction. In addition, the use of tools, such as the GretagMacbeth Color Checker, makes it easy to show students how to fix incorrectly white balanced images using Photoshop®. This paper includes an Equipment, Materials and Facilities List as well as step-by-step instructions for such a shoot. These instructions have been successfully employed in several college-level classes and at the 2004 International Graphic Arts Education Association Conference (IGAEA, 2004).

Theoretical Background

Southworth and Leyda (1998) summarize the attributes of a "good" color reproduction—"Clean and bright is always right. Dull and gray is not the way. People should never be blue or green." Students must understand that these statements are easy to say, but hard to put into practice. These challenges are magnified in the classroom due to the variety of images on which students work and the often-questionable calibration of equipment.

Students must first understand that there are four distinct areas that have the potential to affect the color reproduction of an image. These processes are:

(a) the original image must be captured photographically in such a way that the resultant film or file contains colors closely approximating the original scene;

(b) the image must be appropriately transferred to a properly calibrated computer workstation using, if necessary, a well-characterized color scanner;

(c) image editing software must be properly used to correct or "tweak" the colors in the image; and

(d) either closed-loop or color-managed color separation techniques must be employed to effectively prepare the image to accommodate the specific attributes of the paper, ink, printing process, and press that will be used to reproduce the image.

These processes are difficult, if not impossible, for students to understand without concrete hands-on exercises.

Capturing Photographic Images

Leading up to the demonstration, it is imperative that students understand the physics of light as well as the concepts of absorption and reflection.

As a unit-organizing concept, it is effective to explain that the root words that were combined to create the word "photography" are photos ("light" in Greek) and graphein ("to write" in Latin). Thus, photography is "writing with light" and students must understand the dramatic effect that light has on colorful objects. In particular, an object or scene will appear differently when illuminated with varying light sources. Students must be aware that people seldom notice the effect of a light source on an image. Humans have poor color memory because our brains accommodate for varying illuminations.

Teachers should emphasize that illuminating light strikes the object being viewed or photographed. Some of the illuminating light, known as incident light, is absorbed by the pigments that are inherent in an object. The unabsorbed light is reflected to the viewer of the scene and/or to the camera. The color content of a photographic image, therefore, depends upon the incident light as well as the absorptive and reflective characteristics of the object(s) being captured.

Although the nature of light absorption and reflection by pigments is well known and can be easily taught, the impact of the light source on a photograph is more difficult to explain to students. Teachers need to begin by explaining the impact of white light on a scene. Physically, the on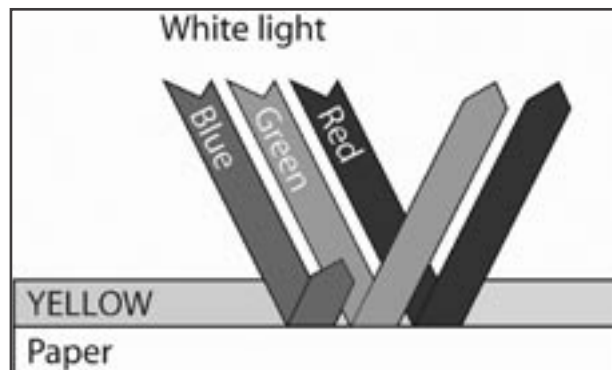ly true white light source is the sun. Unfortunately, sunlight is only truly white when it is unobstructed by the earth's atmosphere, clouds, or air pollution. Therefore, white light is extremely rare.

If white light, which contains equal amounts of red, green, and blue waves, were to strike a yellow apple, then the blue light would be absorbed by the apple and the red and green waves would be reflected to the viewer's eye. The human viewer's brain would combine the red and green waves into yellow (see Figure 1).

Most photographs are captured using light that does not contain equal amounts of red, green, and blue. In particular, artificial light sources, i.e., those created by humans, seldom approximate white and can range from very yellow to blue-green. For example, if an object contains yellow pigment, the yellow will appear muted in blue-green fluorescent artificial light. Similarly, blue pigments will be desaturated if viewed in smoggy, natural sunlight. The human visual system compensates for these variations, but cameras may not.

If the color of the incident light is known, then the photographer can compensate for it during image capture. Begin by teaching students that the color of a light source is measured by its temperature in degrees Kelvin, or ˚K. By way of explanation, zero degrees Kelvin equals -273˚ Celsius and is the lowest possible temperature (NASA, 1999). A standard "object," known as a black-body, is heated to a given degree Kelvin and the color the object glows is noted by using a color temperature meter. Lower Kelvin temperatures, such as 2400°K are red; higher temperatures, such as 9300°K, are blue. Direct sunlight is 4874˚K (X-Rite, 1998).
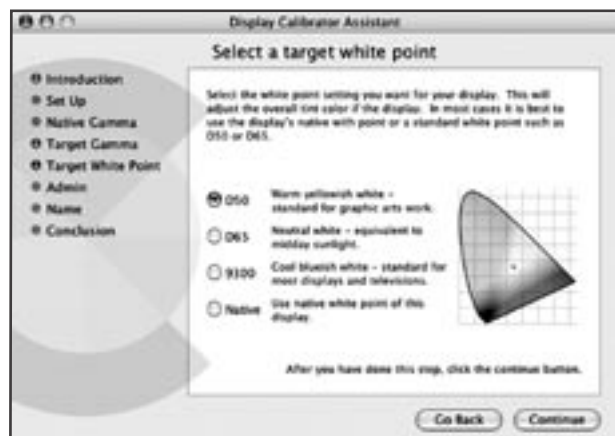

Figure 1

Figure 2

The Commission Internationale d'Eclairage (CIE) used degrees Kelvin in 1931 to specify a series of standard light sources called Illuminants A, B, and C (X-Rite, 1998).

- Illuminant A is 2856˚K and represents incandescent lighting as emitted by standard screw-in tungsten light bulbs.

- Illuminant B represents direct sunlight and is 4874˚K.

- Illuminant C is 6774˚K and represents indirect sunlight such as that known as "northern exposure."

In due course, the CIE refined its color temperature standards to include two specifications for "daylight." These daylight standards are used when viewing color images in printing plants and when calibrating computer monitors (X-Rite, 1998).

- D50 refers to 5000˚K and is the standard for graphic arts viewing and monitors in the United States (see Figure 2).

- D65 refers to 6500˚K and is often used as the standard for graphic arts viewing and monitors in Europe and Asia.

CIE standards were used by film manufacturers to produce films that compensated for the characteristics of light sources. The photographer was required to purchase the appropriate film to match the characteristics of the illuminant to be used during image capture. In particular, film manufacturers sold "daylight" and "tungsten" balanced films.

Use of Filters

Students need to know how photographers can compensate for a mismatch between a color-balanced film and the actual light source through the use of filters. If a photographer captures an image illuminated with tungsten light (Illuminant A) using tungsten-balanced film, the captured image will be properly white balanced because the film was designed to compensate for the lack of blue in yellowish tungsten light. Similarly, a photo taken outside with daylight film would contain the appropriate colors because the film was manufactured with the expectation that white light (i.e., an equal combination of red, green, and blue waves) would be used during exposure.

However, if daylight film is used indoors, the photograph would be too yellow because the film is not designed to compensate for the yellowness of the illumination. Similarly, if tungsten-balanced film is outdoors,

the image would be blue-green because the film is designed to compensate for the lack of blue-green light in tungsten illumination. Of course, both of these scenarios assume that the actual light source is the exact same color temperature as that for which the film was designed. This is a huge assumption and seldom occurs.

Photographers use a color temperature meter to determine the exact color of the illuminant and then install one of a series of filters over their camera lenses to, in effect, change the color of the light source to that for which the film was made (Hirsch, 1993).

Before the advent of digital cameras, the effect of any combination of light source, film, and filter could not be observed until after the film had been developed. Thus, properly capturing color images required a great deal of skill on the part of the photographer. Such skill took time to develop and made it difficult to explain the complex relationship of light source/film/filter to graphic arts students.

Using a Digital Camera to Explain White Balance

Traditionally, one of the only ways to teach students about the effect of light was to force the issue by showing them the same image illuminated simultaneously by varying light sources using a device such as the GTI CRD-1 Color Rendition Demonstrator (see Figure 3) (Color Rendition Demonstrators, 2004).

Today, teachers can easily use digital cameras to demonstrate the impact of the light source on a captured photograph. Most digital cameras provide several

Figure 3

preset white balance settings. For example, the Olympus E-20 camera provides the following presets: automatic, 3000˚K, 3700˚K, 4000˚K, 4500˚K, 5500˚K, 6500˚K, and 7500˚K. To use this feature, the photographer must measure the color temperature of the light and set the camera to the closest preset. Colors are accurate in images captured when the light source and camera setting agree.

In addition to the presets, the Olympus E-20 camera also allows the photographer to set the camera to any other white point by using a white card: simply fill the viewfinder with a white card (or other white item) illuminated by the light source in question and press the white balance button. In effect, this feature allows the camera to act as a color temperature meter and results in photographs that are more accurate than the presets can provide. The use of the Olympus E-20 camera as an example in no way limits the functions described herein to that device. White balance functions are available on most digital cameras.

On the negative side, most digital cameras, by default, set their internal electronics to automatically accommodate for the color of the light source. The camera, in effect, acts like the human brain. In essence, both our brains and digital cameras are designed in such a way as to automatically search out the "whitest" point within the field of vision and consider it "white." This automatic correction is not a problem if there really is a white spot in the image. However, if the scene does not contain white, then the camera's auto white balance function artificially creates one; and the captured image is, as a result, incorrectly color balanced. Students should be taught not to use the auto setting for photographs in which the colors are important.

Using a Color Card During Photo Shoots

Including a color card as part of a photographic image will provide the photographer, graphic designer, and printer with tools to improve color reproduction. For example, the GretagMacbeth Color Checker is "a checkerboard array of 24 scientifically prepared colored squares in a wide range of colors. Many of these squares represent natural objects of special interest, such as human skin, foliage and blue sky"(GretagMacbeth, 2004). In particular, GretagMacbeth Color Checkers provide white, black, and gray patches that can be used to correct or tweak the white balance using image editing software, such as Photoshop®. They also contain representative flesh

tones and other memory colors that can be used to fine-tune color separations to properly render, for example, African-American, Asian, Hispanic, and Caucasian skin tones. Fields, Nichols, and Waite (2003) provide concrete examples of the use of GretagMacbeth Color Checker when rendering flesh tones.

Students should be taught that in practice the Color Checker is included only on the first photograph of a shoot containing multiple images captured with the same light source. Eventually, adjustments can be made to this first image in an image editing program, such as Photoshop®. Depending upon the image editing software, these series of adjustments can be saved in a macro, such as a Photoshop® "action." This macro can be used to automatically correct the shoot's remaining images.

Once the students understand color theory, they are ready for the hands-on photo shoot activity.

Hands-On Photo Shoot Activity

Teachers can set up a simple or elaborate photo shoot and capture multiple images of the same set using varying light sources and/or the white balance capabilities

Figure 4

of a digital camera. Students should be involved in the staging of the set. The student "model" should come to class the day of the shoot dressed in a combination of gray and bright colors. The remaining students in the class should bring some small, very colorful, items on the day of the shoot. See Figure 4 for an example of a set in a light-controlled space including the placement of the GretagMacbeth Color Checker.

The camera's preset white balance settings, as well as any "white card white balance" feature, should be utilized in the class "shoot." Several lighting scenarios should be developed based on the light sources available to the instructor (for example, tungsten, fluorescent, flash, and combinations of these). For each lighting condition, the set should be photographed using each white balance setting that the class camera can accommodate. Complete and accurate documentation of each combination of lighting condition and white balance setting should he recorded on a Photograph Record Sheet (see Figure 7 in the Appendix).

Once the images have been captured, they should immediately be downloaded onto the teacher's hard drive and displayed for the class using a calibrated monitor or projection system. Careful attention should be paid to the effect of each light source and each camera setting on the resultant image. Teachers should explain which images are correct and why the others are wrong. In addition, teachers should explain how the combination of light source and camera setting resulted in each good—and each incorrect—image.

Importance of Monitor Calibration

Students must be taught to calibrate (and re-calibrate) their monitors to the CIE D50 standard so that the colors they see on the screen can be properly judged. Monitors that are uncalibrated, or set to their native white points, generally skew colors toward blue. This colorcast must be eliminated.

The relative "warmth" of a monitor set to D50 may surprise students. Many will balk at the change. Teachers should stand firm and emphasize that D50 is not only correct but that the calibration should be checked and adjusted frequently (i.e. daily) to make sure the setting remains accurate. Either the operating system's built-in visually based calibrator or an external third party monitor calibrator, such as X-Rite's Monaco Optix system or

PANTONE's Spyder2, may be used.

Correcting Improperly White-Balanced Photos

The popular image editing software, Photoshop®, has three tools in the Levels and Curves dialog boxes that make it easy to correct improperly white-balanced photos: the "Set White Point," "Set Gray Point" and "Set Black Point" tools (see Figure 5).

Assuming that the GretagMacbeth Color Checker has been included as part of the image being adjusted, it is a simple matter to click on a gray patch of the Color Checker with the "Set Gray Point" tool. Use of this tool almost always causes an incorrectly white balanced image to become more accurate. If necessary, the "Set White Point" and "Set Black Point" tools can be used to further refine the white balance. Caution is necessary when using the "Set White Point" tool so that the highlights do not become too white.

Using the "Set White Point," "Set Gray Point," and "Set Black Point" tools, it is possible to correct most incorrect images captured during the photo shoot so that they closely match those in which the light source and camera settings agree.

When correcting the first image of a shoot captured using a given light source, the process can be recorded

Figure 5

using Photoshop's Actions command so that the process can be replayed on subsequent images.

It is also important for students to learn the importance of flesh tones and other memory colors and how to adjust them using Photoshop's functions. If the photograph in question contains an image of a human, it is important to check the flesh tones. *CMYK Color, Visual & Digital References for Professionals* (Fields, Nichols, and Waite, 2003) includes example photographs of persons from each racial group along with representative color content for their skin tones. In addition, examples of what happens when flesh tones are improperly color balanced are provided.

A complete set of instructions for using image editing software to correct photos for white balance is provided in the Appendix of this paper.

Conclusion

By presenting the theory and the hands-on demonstration suggested in this paper, students can quickly and effectively grasp the impact of the light source on a captured image. In addition, students will learn to use the somewhat obscure white balance settings available on most digital cameras. They will learn the importance of calibrating their monitors to industry standards and how to correct improperly white balanced photographs using an image editing program, such as Photoshop®.

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Biographical Information

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Appendix

Step-by-Step Instructions
for a Classroom Demonstration

Equipment, Materials, and Facilities List

1. Room in which lighting can be controlled (a photographic darkroom is appropriate.

2. Multiple light sources (for example, D50 fluorescent lighting, D50 plus red safelights, incandescent studio lights, or camera flash). These light sources can be as simple or elaborate as necessary.

3. Digital still camera that allows the White Balance to be adjusted. Check your batteries.

4. Tripod

5. Memory card that will hold sufficient photos (40–50 photos is an appropriate number) at the camera's highest resolution. You may want to erase the memory card.

6. A "set" of some sort, such as a table, chair, and potted plant.

7. GretagMacbeth Color Checker or equivalent (large gray-scale, neutral gray card)

8. Photograph Record Sheet (attached)

9. Computer(s) equipped with Adobe Photoshop 4® or above and iPhoto® or Adobe Photoshop Album® or equivalent.

10. A teacher's computer workstation with LCD projector is very useful.

Prior to the Lesson

1. Enlist the assistance of a student to be the "model" for the upcoming photo shoot. The student should come to class dressed in a combination of neutral (gray) and bright colors.

2. Ask all remaining students to bring some small very colorful item to class on the day of the photo shoot.

3. Prepare the "set" in your light-controlled space (see Figure 4).

4. Mount the digital camera and flash on the tripod.

The Photoshoot

1. Pose the model in the set previously prepared above (see Figure 4).

2. Position the students' colorful items.

3. Position the Gretag-Macbeth Color Checker or other gray card as shown in the example.

4. Identify a photographer and a recorder. The instructor may act in either capacity or may have two students assume these roles.

5. Illuminate the set using a given set of lights (this will be known as lighting scenario #1) and record that scenario on the Photograph Record Sheet.

6. Photograph the set using each white balance setting your camera can accommodate. Be sure to keep accurate and complete records of each shot including frame number, lighting condition, and white balance setting.

7. Illuminate the set with a different kind of lighting (lighting scenario #2) and record that scenario on the Photograph Record Sheet.

8. Photograph the set using each white balance setting your camera can accommodate. Be sure to keep accurate and complete records of each shot including frame number, lighting condition, and white balance setting.

9. Repeat steps 7–8 until all lighting conditions have been exhausted.

Downloading and Sharing

1. Connect the digital camera to the instructor's computer and download the photos into iPhoto® or Adobe Photoshop Album® or equivalent.

2. If possible, project the photo album so that all students can see.

3. Have your "model" close at hand so you can compare that individual's flesh tones and clothing colors to those displayed on the computer or LCD screen.

4. Describe each of the several photos captured with lighting scenario #1. (Use the Photograph Record Sheet to determine which image was photographed with each lighting scenario and camera setting.) Explain why each photograph appears so different from the others shot in the same lighting.

5. Explain the differences between the photos shot using lighting scenario #2 and those shot with lighting scenario #1 using the same camera setting. Explain that both the camera's white balance setting and the light source must agree to get good photos the first time.

6. Share all or some of the photos with your students using the network, server, memory cards, disks, or whatever media you have at your disposal.

Figure 6

Quick and Easy White Balance Correction in Photoshop®

1. Use iPhoto® or Adobe Photoshop Album® to open an incorrectly color-balanced photograph in Photoshop®. (You may want to set the preferences in iPhoto® or Album so that the program opens a selected photograph in Photoshop®.)

2. Open the Curves Dialog Box.

3. Select the Gray Balance Tool.

4. Move the cursor over any one of the gray-scale swatches along the bottom of the GretagMacbeth Color Checker (or other gray scale or card) (see Figure 5).

5. Click on the gray swatches—one at a time—and observe the instant improvement of the color balance.

6. You may also wish to experiment with the Black Tool. Select it, then move the cursor over the blackest swatch on the GretagMacbeth Color Checker and click (see Figure 6).

7. When you are finished, click "OK" to return to the photograph.

8. Save the file if desired. It is most appropriate to save it with a different name: for example, append the phrase "white_balanced" to the end of the name.

9. Open several different incorrectly photographed images and use the Gray Balance Tool and Black Tool to correct them.

10. Explain to students that they can save the changes they apply to the white balance of the image by clicking the "Save" button in the Curves dialog box.

a. This saved curve can then be applied to every other image shot with the same lighting and white balance setting by selecting Load in the Curves dialog box.

b. The saved curve means that only one photograph—the initial one—of a photo shoot needs to have the GretagMacbeth Color Checker, other gray scale, or card included. All other images can be instantly corrected—even in a batch process—by applying the saved curve.

Photograph Record Sheet

Image Number	Lighting Scenario	Camera Light Balance Setting
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
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Figure 7

Online Education: A Survey of Graduate Students' Perceptions and Attitudes

by Dr. Lesta Burgess and Dr. Ronald O'Meara, University of Nrthern Iowa

Educators today are using distance education and Internet-based learning as methods for delivering courses. Teaching styles have to be adapted to this new environment because the Internet is a different medium. Faculty and students have to adjust to the pedagogy that uses instructional technology as an integral component in teaching. Many faculty who have not used instructional technology to accomplish course objectives in the past now have to be trained to do so, and they very often include a component in the course that provides information to students about the teaching itself (Hazari, 1998). Students must be trained in instructional technology in order to be successful with online learning classes.

The past decade has witnessed the widespread development and delivery of distance education courses (Smallwood & Zargari, 2000). In the mid 1990s, Peterson's guide reported that nearly 400 accredited colleges and universities in North America provided students online instruction of some sort (Velsmid, 1997). If a school ignores this chance to deliver courses via distance education, it faces losing students to other institutions that act quickly to exploit a new method of reaching them (Kroder, Suess & Sachs, 1998).

The purpose of this study was to examine graduate students' attitudes, perceptions and skills regarding Web-based distance education to determine their preferences and experiences with Web-based education.

Distance Education

Distance education, the transmission of instruction from one location to multiple locations via telecommunications technology, has expanded at an exponential rate in post-secondary education settings (Smallwood & Zargari, 2000). This exchange of information between instructor and student can be in the form of compressed video/interactive television (ITV), video conferencing, satellite transmission, Internet, or Internet-based delivery used separately and/or in combination with traditional modes of instruction. Access to distance education may require students to be at a specific location at a specific time, such as with ITV, or the course can be made available via electronic files and accessed at the student's convenience. This is the case with Internet-based courses (Smallwood & Zargari, 2000). Thus, the more traditional method of teaching via lecture or face-to-face interaction could potentially be supplanted by students learning at their own pace, on their own time, and at any location with an Internet portal (Whitehead, 2001).

Internet-Based Learning

The use of the Internet as a tool for Internet-based learning (also called e-learning) has educators rethinking the way instruction is administered to students. Internet-based communication creates a variety of ways to deliver instruction and provide electronic resources for student learning. Some methods, such as using Web pages to deliver text in much the same way as hard bound texts, are very familiar to faculty. However, a big advantage is that the Internet also supports the delivery and use of multimedia elements, such as sound, video and interactive hypermedia (McNeil, Robin & Miller, 2000). Curriculum, administration, and assessment are all affected as members of the educational community experience changes in communication and commerce that are a result of the explosive expansion of the Internet (Austin & Mahlman, 2001).

Thus, many educators are looking at the way Internet-based learning can provide flexibility and convenience. Internet-based learning can overcome some traditional barriers such as time and place. A student can study independently online or take an instructor-led online class, which combines the benefits of self-study with those of more traditional classroom-based learning (Ryan, 2002). Since working adults occupy an increasingly large percentage of our college population, and because increasing numbers of students have computer and Internet experience prior to entering college, opportunities are being made to better meet their needs, interests, and work schedules through online classes (Cooper, 2001). As university level technology education programs begin to offer more online classes and degree programs, technology education professors may be in the position of developing online offerings (Flowers, 2001).

Internet-based learning does not require extensive computer skills, although familiarity with computers and software (especially Web browsers) does help to reduce the intimidation factor (Ryan, 2002). Internet-based learning generally fits into one of three major categories:

Self-paced independent study: The student determines the schedule and study at their own pace. They can review the material for as long as necessary. Feedback from online quizzes takes the form of preprogrammed responses. Unfortunately, there is no one to whom the student can direct questions. This form of study requires the most self-motivation.

Asynchronous interactive: The students participate with an instructor and other students, although not at the same time. They attend classes whenever they need or until the course material is completed. This approach offers support and feedback from the instructor and classmates. It is usually not as self-paced as independent study.

Synchronous learning: Students attend live lectures via computer and ask questions by e-mail or in real-time live chat. This format is the most interactive of the three and feels the most like a traditional classroom. Flexibility is limited because of the previously determined lecture schedule. There are limited course offerings in this format due to high delivery costs (Ryan, 2002).

Positive and Negative Aspects of Internet-Based Learning

Proponents argue that Internet-based courses actually do better than traditional instruction at discouraging student passivity and encouraging lifelong learning (Rosenbaum, 2001). Since Internet-based instruction is such a new medium, evidence of effectiveness of online courses compared to traditional instruction is lacking (Hazari, 1998). It is true that in an interactive, multimedia environment, students often find greater opportunities to learn by actively working through new concepts. This, of course, is dependent on the structure and kind of Internet-based learning tools made available to the student. For example, relatively low-tech presentations delivered online allow students to proceed slowly or click past material they already know. Ideally, Internet-based learning also promotes group learning and inquiry via serial e-mails known as "discussion threads" (Rosenbaum, 2001). Instructor tools that can improve or enhance classroom management include e-mail, digital drop box, discussion board, and the chat room. These tools can enable students and the instructor to have broader access to one another as needed (McEwen, 2001).

The advantages of Internet-based courses include: students can determine the time and place of learning; students have access to global resources and experts; students can engage in courses at home or at work; scheduling; flexibility; and the ability to track progress (Smallwood & Zargari, 2000; Gallagher, 2001). While Internet-based course have advantages, it is equally important to note there are disadvantages. These might include: little or no "in-person" contact with the faculty member; feeling isolated; learning curve in how to navigate the system; occasional technology problems; the student must be actively involved in the learning; and increased lead-time for feedback regarding assignments (Smallwood & Zargari, 2000). Another disadvantage may be the lack of availability of the hardware and software necessary for Internet-based learning.

There appears to be a lack of supporting evidence in the literature indicating a preferred method of instructional delivery. As a result, a survey instrument was developed to determine skills, perceptions, and attitudes of delivering Web-based courses to graduate students in an Industrial Technology program.

Instrument Validation and Pilot Testing

The validity and reliability of the instrument was ensured by experts in related field as well as through a pilot test. The questionnaire was sent to five university faculty for validation. They were asked to evaluate the content of the questionnaire and to comment on the clearness and appropriateness of the items. Before implementing the survey, a pilot test was administered to fifteen graduate students. The fifteen graduate students were randomly selected from students enrolled in graduate courses during Spring Semester 2004. The population source for the students was 43 students. The purpose of the pilot test was to check the time it took to finish the questionnaire, to avoid ambiguity and format problems, and to clarify the items. The suggestions, questions, and comments from the randomly selected students and faculty were taken into consideration to make the questionnaire clearer and more understandable. According to the results of the pilot test group, the researcher made the necessary corrections. A cover letter was developed and included information on the purpose of the study and the confidentiality of responses. A Likert-scale was used for responding to content items, with the five ratings being: 1 = Strongly Disagree; 2 = Disagree; 3 = Undecided; 4 = Agree; and 5 = Strongly Agree.

The survey instrument was specifically designed to assess skill level, attitudes, and perceptions regarding Web-based education. The survey instrument was divided into four parts. In Part 1, questions were asked to seek the skills with computers, world wide-web, and web-course management tools related to design, development, and delivery of Web-based courses. Part 2 focused on attitudes regarding web-based distance education. Part 3 reviewed students' perspectives on web-based distance education, and Part 4 provided demographic information. Demographic information was not collected on the survey instrument for age, gender, or education level.

Data Analysis

The findings are based on an analysis of the questionnaire responses. A total of 60 survey questionnaires were sent out to graduate students in an Industrial Technology program. A total of 24 questionnaires were returned, a response rate of 40%. The data were analyzed using the Statistical Package for the Social Sciences (SPSS). Summary descriptive statistics were generated from the responses to the questionnaire. In addition, correlations were run to determine if there were any relationships between the variables. The results are shown in the Tables 1 and 2.

Findings

Table 1 shows the mean scores in descending order for the questions in Part 1. Of the ten questions, seven of the subject categories had a mean rating of 4.0 (agree) or higher. The remaining three subject categories were rated between 2.92 and 3.00, with 3.0 being undecided. The questions with the higher mean ratings indicate that students are very comfortable with using search engines, plug-in software, web-browsers, and understanding the basic concepts of computer software and hardware. When reviewing the three questions with the lower ratings, students were less confident in their skills for Web

Subject Categories	Mean	N
1. Understanding basic concepts of hardware	4.53	24
2. Understanding basic concepts of software	4.25	24
3. Installing software is not difficult	4.21	24
4. The use of web browsers	4.54	24
5. The use of plug-in software	4.33	24
6. The use of search engines	4.71	24
7. The use of online applications	4.46	24
8. Web-page design using HTML	2.92	24
9. Web-page design using authoring software	3.00	24
10. WCM tools (WebCT, Blackboard, etc.)	3.17	24

Table 1: Skill with computers, World Wide Web (WWW), and Web Course Management

Subject Categories	Mean	N
1. Web-based education has a positive future	4.21	24
2. Web-based education is an effective tool	3.92	24
3. Prefer traditional instruction vs. web-based instruction	3.25	24
4. Desirable option for earning academic degree	3.54	24
5. Will require additional time beyond classroom	3.21	24
6. Student will need extra time to complete the course	3.17	24

Table 2: Attitudes regarding Web-based Distance Education

page design using Hypertext Markup Language (HTML), authoring software (i.e., Frontpage, Dreamweaver, and so on), and the use of Web Course Management (WCM) tools such as WebCT, Blackboard, and Top Class.

Table 2 shows the mean scores in descending order for the subject categories in Part 2 of the survey instrument. This section concerned the attitudes of students regarding Web-based distance education. All of the responses were rated between 3.17 and 4.21, which reflects students being somewhere between "undecided" and "agree" on the scale. Most of the respondents have limited experience with distance education, and this is reflected by the mean rating of the responses in this section.

In Part 3 of the survey instrument, students' perspectives on Web-based distance education were reviewed. When asked if they had ever taken a web-based distance education course, 67% of the graduate students who completed the survey responded "no." Therefore, only 33% of the respondents answered the question with a "yes" response. When asked if the thought of taking a web-based distance education course appealed to them, 67% responded "yes" and 33% of the respondents stated "no." Finally, when asked if they would like to complete an entire graduate program via web-based distance education, 75% of the respondents replied "no" with the remaining 25% stating "yes."

Correlations were run on the three questions in Part 3 of the survey. Table 3 shows that there was one correlation that was significant at the 0.05 level: the relationship between taking a web-based distance education course and the idea of taking a complete graduate program via web-based distance education. As can be seen, the result of a Spearman's rho correlation revealed that there was a significant relationship between taking one web-based course and completing an entire graduate program via web-based. Reporting the results statistically, $r = 0.408$, $N = 24$, and $p < .05$ level (2-tailed).

Conclusions

The purpose of this survey was to determine graduate students' preferences and experiences with Web-based education. Specifically, the survey was constructed to examine graduate students' attitudes, perceptions, and skills regarding Web-based distance education. The questionnaire results indicated many interesting findings for the students surveyed. Most of the students surveyed were comfortable understanding and using basic computer hardware, software, and web-browsers. In addition, the students were comfortable with the use of on-line applications and search engines, scoring somewhere between "agree" and "strongly agree" on the Likert scale. When looking at the responses related to creating or developing Web pages using HTML or authoring software, the ratings for those questions were "undecided" on the Likert scale.

Of the responses, 67% of the students have never taken a web-based course. However, most of the students thought the idea of taking a course via the web was appealing. The data indicate that students like taking some coursework via distance education to earn a degree, but prefer having the traditional method of face-to-face delivery and classroom interaction for the majority of their courses.

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	Web Course	Grad Program
Spearmans rho Sig. (2-tailed)	1.000	0.408 0.048
Spearmans rho Sig. (2-tailed)	0.408 0.048	1.000

Table 3: Correlation for one Web-based course and completing an entire graduate program Web-based.

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Prepare manuscripts according to the APA style, including the reference list. Submit a maximum of ten word-processed, 8.5" X 11" pages in 12 point type and double spaced (excluding figures, tables, illustrations, and photos). Also, provide a short biography for yourself that can be used if the article is accepted for publication. All articles must be submitted in electronic form and as a hard copy. Articles can be submitted on a CD-ROM or as an e-mail attachment. The text should be submitted in Microsoft Word format. Do not submit documents created in page-layout programs. Call out the approximate location of all tables and figures the text. These call-outs will be removed by the editor. List your name and address on the first page only! Article text should begin on the second page.

Artwork

Be sure that submitted tables and other artwork is absolutely necessary for the article, and that each one a caption. Electronic artwork is preferred and should in EPS or TIFF format. Send all artwork files and hard copies of these files with your submission. Scan photographs at 300 ppi resolution. Scan line drawings 800 ppi resolution. Screen captures should be as large possible.

Submittal of Manuscripts

All manuscripts must be received by the editor no later than December 15th to be considered for the next year's *Journal.* The manuscript packet must include digital hard copies of all text and figures. Prepare text and artwork according to the instructions given in these guidelines. Be sure to include your name, mailing address, email address (if applicable), daytime phone number with your materials.

Acceptance and Publication

If your article is accepted for publication, you will notified by e-mail or mail. The *Visual Communications Journal* is generally published and distributed in the summer of each year.

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