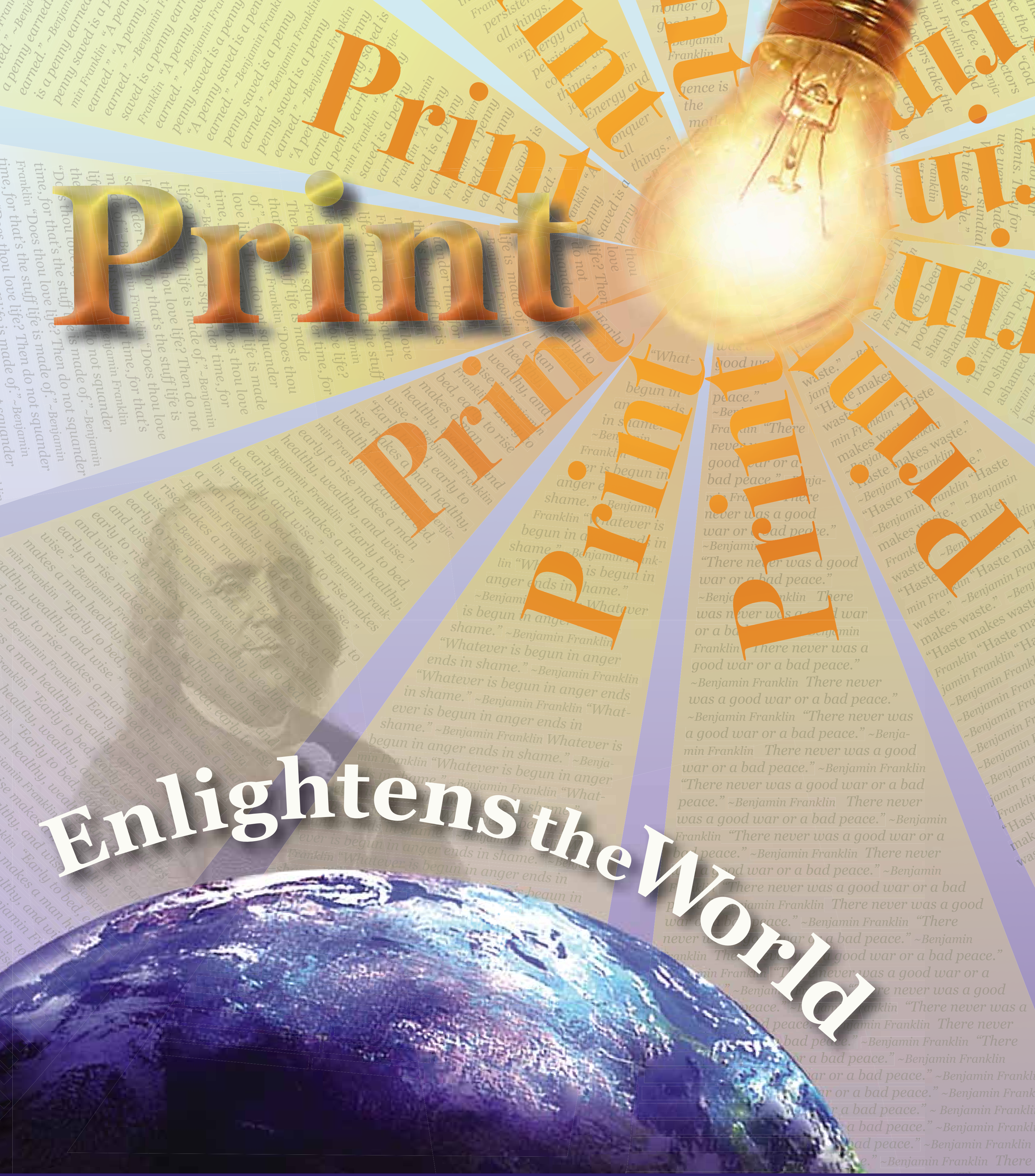

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About the Journal

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Table of Contents

Editor's Note

by Jerry J. Waite, Ed.D, University of Houston

As always, this issue of the *Visual Communications Journal* has something for everyone involved in graphic arts and graphic arts education.

Quality control is definitely a primary focus of this *Spring 2010 Visual Communications Journal.* Yung-Cheng Hsieh, from National Taiwan University of Arts, investigated the positioning of frequency-modulated (FM) and amplitude-modulated (AM) segments of the tone range to produce an optimal hybrid-screening scheme. He found that using 0–5% FM, 6–85% AM, and 86¬–100% FM provides the overall best results when measuring the print-quality attributes of tone value increase (TVI), ink trapping, print contrast, hue error, and grayness.

Naik Dharavath, a professor at University of Wisconsin-Stout, explored the use of color management in his department's new Color Management and Control Lab. Using the latest hardware and software, he found that a Color Management Workflow made it possible for his printers and monitors to produce nearly identical colors. Naik's detailed explanation of the method he used to conduct his study can be used as a basis for faculty to teach this all-important quality control process.

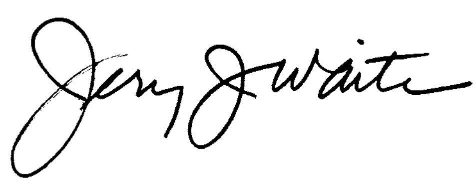
Patricia Sorce, from Rochester Institute of Technology, assessed the changing workforce requirements in the printing industry due to the addition of new value added-services to the printer's repertoire. These newly-added services may include: Variable Data Printing (VDP), Graphic Design, Web Site Design, Digital Asset Management (DAM), and Database and Direct Marketing services. Patricia found that the expansion of digital services across all types of printing firms has maintained a steady need for employees with these skills. Graphic Communications educators need to consider Patricia's findings as they update their curriculums and laboratories.

Chris Lantz, from Western Illinois University, provides a look at instant photo technologies and explores ways that these technologies can be incorporated into photography curriculums at a minimal cost. Using Polaroid or Fuji instant film and relevant cameras, students can learn valuable photographic concepts…concepts that can easily be transferred to the latest digital photographic techniques.

Finally, Suanu Wikina and Cynthia Carlton Thompson, from North Carolina A&T State University, provide printers and graphic communications faculty with a blueprint for incorporating "resourceful thinking" into their business plans and curriculums. Resourceful thinking is about finding the best tool to get the job done; lowering running costs; getting more for less while eliminating or reducing negative impact on the environment; and assessing energy, paper, carbon impact, and associated monetary costs. This timely article is directly relevant to the 2010 IGAEA Conference theme: *Sustainability: Our Discipline, Our Programs, Our Future.*

As is often the case in our small-but-productive profession, two articles that appear in this edition of the *Visual Communications Journal* were authored by the Journal's reviewers (Chris Lantz and Cynthia Carlton-Thompson). Chris' article was submitted to the same peer-review scrutiny as the other papers and was accepted using a double-blind review process. In addition, a unanimous positive vote by the reviewers to publish the article as a juried publication was received. Documentation regarding the voting on this article is available by contacting me at jwaite@uh.edu. Cynthia Carlton-Thompson's paper is an edited article. Thus, it did not go through the peer-review process and was accepted by me in my role as editor.

Thank you to the Journal's Editorial Review Board. I truly appreciate the time and effort invested by Cynthia Carlton-Thompson, James Tenorio, Zeke Prust, Bob Chung, Malcolm Keif, Chris Lantz, and Mark Snyder.



Optimum Flexible Hybrid Screening for Offset Lithography

by Yung-Cheng Hsieh, Ph.D., National Taiwan University of Arts

Abstract

This study investigated the use of AM/FM (Amplitude Modulation/Frequency Modulation) hybrid screening in conjunction with computer to plate (CTP) technology in order to obtain an optimum hybrid screening combination for the offset lithographic printing process. The study designed eleven different hybrid (FM-AM-FM; highlight-midtone-shadow) screening combinations in accordance with one of the few flexible (adjustable) hybrid screening technologies. Hybrid screening and CTP technologies were used in offset lithography to print a digital test form (modified from the GATF Digital Test Form 5.0 and ECI2002R) on matte-finish paper. Differences in print attributes between matte-finish paper printed via the eleven hybrid screening combinations were measured by a spectrophotometer, and statistical analyses were used to identify a combination with an optimum FM-AM-FM tone percentage. The main result of this study found that the most optimum FM-AM-FM screen combination is 20-70-10 (i.e., 0%~20% is FM; 21%~90% is AM; 91%~100% is FM). It is hoped that the results of this study can help offset lithographic printers to better understand the characteristics of various screening techniques, allowing them to improve printing quality and achieve the highest customer satisfaction. The best hybrid screening combination of FM-AM-FM (highlight-midtone-shadow) found in this study is provided to printers as a reference enabling them to improve production effectiveness and quality, while reducing printing costs and waste, enabling the quality of offset lithography in Taiwan to progress.

Introduction

Research Motives, Questions, and Objectives

The screen used in the Amplitude Modulation (AM) screening technology, commonly employed by the conventional printing industry, consists of a grid of fixed-pitch dots that are made smaller or larger to simulate continuous tone and to achieve the desired color and contrast. Unsatisfactory manifestation in the highlights and shadows may be often observed due to the fact that screen angle, screen ruling (lines per inch), and screen shape are all invariable. These problems have given rise to the emergence of Frequency Modulation (FM) screening technology. FM screening achieves color and contrast by clustering dots of the same size. The density of dots then translates into variations in tones. However, since the problem of tone value increase (TVI) is more serious in FM than in AM, AM would have a better performance in midtones than FM (Dan Blondal, 2003). Based on advantages from AM and FM screening technologies, flexible (adjustable) hybrid screening technology generates optimal printing quality by integrating advantages of both technologies. The study was designed to apply a flexible (or adjustable) hybrid screening technology to offset lithography on coated paper for the purpose of investigating the optimum hybrid combination to achieve satisfied print attributes.

The so-called flexible or adjustable hybrid screening technology in this research means that the transition points (lines) between FM and AM can be freely controlled by the user. The main question that the study tried to answer was whether various flexible hybrid screening combinations in lithography really performed differently on tone reproduction, solid ink density, print contrast, ink trapping, grayness, and hue error. Did any particular FM-AM-FM hybrid combination yield better print attributes than others under the same print condition?

By using FM-like screening techniques and random arrangement of dots, hybrid screening technology has been developed to reproduce better details in highlights and shadows and allow an extended tonal spectrum. In addition, flexible hybrid screening offers operators choices to set, according to their needs, a specific percentage of dot density at which one screening technology (AM or FM) will be transited to the other (FM or AM) (Flexo CtP Developments Announced by Creo, 2003). The main objective of this study was to find out an optimal FM-AM-FM (highlights-midtones-shadows) flexible hybrid screening combination for offset lithography by printing different combinations on matte-finish paper and measure print attributes thereof.

Conceptual Framework

Conceptual Framework

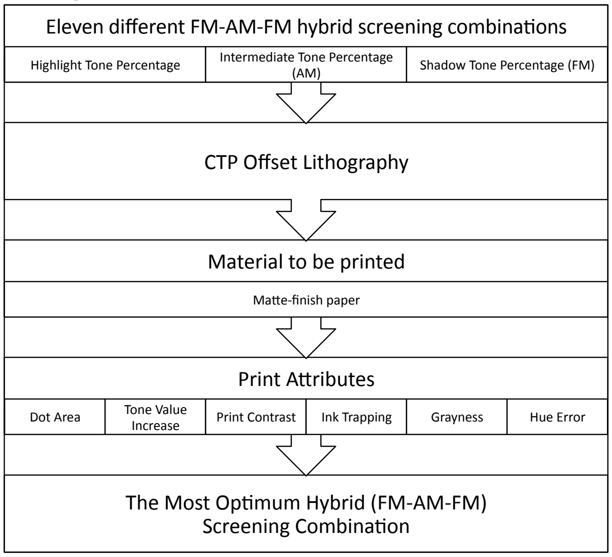


Figure 1

Research Hypotheses

Based on the objective of this study to identify an optimum FM-AM-FM hybrid screening combination for identifying printing attributes in offset lithography on matte-finish paper, the following hypotheses are proposed:

Hypotheses

Ho: With output from the same original, printed by the same offset lithographic press, measured by the same instrument, there is no significant difference among different percentage combinations in hybrid screening offset lithography print attributes (tone value increase, print contrast, ink trapping, hue error and grayness) on matte-finish paper; that is:
Ho: $\mu_{PA/i} = \mu_{PA/j}$ (In which μ is a mean value of the print attribute measured, PA indicates print attribute, i indicates one of the 11 combinations, j indicates one of the 11 combinations, but $i \neq j$.).

Ha: With output from the same original, printed by the same offset lithographic press, measured by the same instrument, at least one pair of different percentage combinations exhibits significant difference in hybrid screening offset lithography print attributes (tone value increase, print contrast, ink trapping, hue error and grayness) on matte-finish paper; that is:
Ha: $\mu_{PA/i} \neq \mu_{PA/j}$ (In which μ is a mean value of the print attribute measured, PA indicates print attribute, i indicates one of the 11 combinations, j indicates one of the 11 combinations, but $i \neq j$.).

Research Assumption and Limitations

1. According to General Requirements for Applications in Commercial Offset Lithography (GRACoL), solid ink density (SID) in this study was set at K1.70, C1.40, M1.50, Y1.05 during the experiment.
2. GATF (Graphic Arts Technical Foundation) Digital Test Form in a format of 28×45 (cm) was used with modifications to fulfill the needs of this study.
3. The use of printing material (except for substrate) and equipment in printing experiments of this study are of the same routine of standard printing houses.
4. Room temperature and relative humidity during printing experiments in this study are set at 25°C and 60%, the same as those at printing houses.
5. Plate making in this study imitates no tone compensation curve.
6. Instruments, such as the GretagMacbeth Eye-One iO, used in this study to measure print attributes, have all been launched and marketed by respective manufacturers. The reliability and validity of these instruments have been confirmed by both academic and industrial circles and will not to be discussed in this study.

Literature Review

Hybrid Screening Technology

Conventional AM screening technology exhibits rich tones in midtones and higher LPI figures yield better detail. Nevertheless, confined by environment or capabilities of the printing machine, higher LPI does not necessarily means a better reproduction result. Moiré, rosette, and tone jumping are problems commonly seen in AM screening technology. Although FM screening technology is free from moiré and rosette, and exhibits tones better than AM does, it has serious tone value increase and noise problems.

FM differs from AM in several ways. In addition to the size and density of dots, the method of tone formation also leads to different figures in print attributes. FM differs slightly from AM in solid ink density (SID), about ±0.1 density unit; 10% difference in tone value increase

(TVI); 20% loss of shadows in print contrast (PC); not much difference in gray balance (GB); and considerable smoothness in skin tone.

Due to the fact that FM and AM technologies each have their own advantages, in order to improve printing quality and reproduce true-to-life images, the printing industry sought to employ advantages, yet avoid disadvantages, from both. This gave rise to the emergence of Hybrid screening technology.

Hybrid screening technology possesses advantages from FM and AM. FM Screening is used for highlights and shadows while AM Screening for midtones. This not only removes noise from FM in the highlights, but improves the rosette from AM and allows better images to be reproduced (See Table 1).

Table 1: A comparison among FM, Hybrid and AM screening technology

	FM	Hybrid	AM
Fine details	Yes	Yes	Depending on LPI
Smooth tones	Smooth	Smooth	High LPI may cause tone jumping
Print stability	Average	Stable	Stable
Moiré	None	None	Yes
tone value increase	Serious	Average	Average
Noises	In highlights	Vary from different combinations	Less

Although it has advantages from AM and FM, the use of hybrid screening technology does not guarantee a perfect reproduction of images. Drawbacks may include the following:

1. Boundaries between AM and FM tend to be obvious.
2. The technology is complicated and it will take quite some time in calculation.
3. Due to different configuration technologies, noise may be introduced in midtones.

Print Attributes

Conventional printed images are comprised of dots of different sizes and quite a lot of variables have to be under control during printing processes so as to ensure perfect printed sheets. The print house would have to know which print attributes are most important to the customer. These may include density, brightness, print contrast, hue and color saturation. Through combinations of different screening technologies, this study aims at analyzing the difference in print attributes and color quality among different formats and different substrates.

Dot Area

Dot area can be classified according to Film Dot Area (FDA), Effective Dot Area (EDA), or Practical Dot Area (PDA).

1. Film Dot Area indicates the dot area on the film.
2. Effective Dot Area, also referred to as optical dot area, is Film Dot Area plus tone value increase, or the dot area one sees after printing. Murray tried to calculate dot area from the relationship between halftone density and SID in 1936 and the Murray-Davies Equation was deduced afterwards. Based on the assumption that incident light on the paper will be totally reflected and there is no diffusion, the dot area can be obtained when the density of the paper is set to zero. Since multiple reflections within the paper are ignored, the dot area calculated is the dot area on the paper plus optical tone value increase. Through this equation, optical tone value increase perceived by human eyes when looking at the paper can be better simulated. The equation is as follows:
   $EDA = \frac{1-10^{-Dt}}{1-10^{-Ds}}$ (D^t: density of halftone dots, D^s: SID).
3. Practical Dot Area, also referred to as Yule-Nielsen equation, introduced an *"n"* value into the Murray-Davies equation to compensate multiple reflection and diffusion on the paper aiming for the actual dot area on the paper. (Brehm, 1992) This is because light from all directions, as well as light of diffusion, will hit the paper. Still, multiple reflections will occur once the light hits the paper. With the Murray-Davies Equation, actual dot area apparently cannot be obtained. The equation is as follows:
   $PDA = \frac{1-10^{\frac{-Dt}{n}}}{1-10^{\frac{-Ds}{n}}}$ D^t: density of halftone dots, D^s: SID).
   (n: a parameter for the correction of multiple reflections and diffusions.)

Tone Value Increase (TVI)

In printing, tone value increase refers to the difference in dot area between film and plate or between film and paper. TVI may occur during color separation, film exposure, plate developing, and ink transfer from printing machine to the paper. Such changes of area are inevitable in printing processes that involve ink carry and transfer. In lithography, TVI has been confirmed a key factor influencing printing quality (Hsieh, 1997). It would be beneficial to a print house to understand the types, causes, influencing factors of, how to calculate, and how to control TVI so as to have better control over printing quality (Killeen, 1995).

Tone value increase includes physical tone value increase and optical tone value increase. Physical tone value increase is mechanical dot area enlargement which may occur during plate-making processes; or when ink, paper and other printing conditions are changed; or during printing processes. Optical tone value increase, a TVI resulting from reflections and refractions of light on paper (substrate), may occur during printing processes. Optical tone value increase tends to cause dots of different sizes to enlarge to the same size making dots in highlights, midtones, and shadows change diameters. The longer the circumference becomes, the bigger increase in dot area. The biggest TVI occurs in midtones, or 50% of the total dot area (Southworth M. & Southworth D., 1989, Ch.14–13—Ch.14–14) as shown in Figure 2.

Physical tone value increase is mechanical dot area enlargement that occurs during film output, plate-making processes, or when ink, paper and other printing conditions are changed (Southworth, M. & Southworth, D., 1989, Ch.14–13). Physical TVI during printing processes may enlarge uniformly along the peripheries of dots, while irregular TVI may also occur due to errors in printing, such as slur or doubling. A density measuring instrument is generally used in determining various print attributes such as dot area, SID, print contrast, and ink trapping. The Murray-Davies equation and Yule-Nielsen equation are two equations commonly used in calculating dot area.

Tone value increase curve.
Source: Quality and Productivity in the Graphic Arts (Ch.14–15) by Miles Southworth & Donna Southworth, 1989, New York: Graphic Arts Publishing Co.

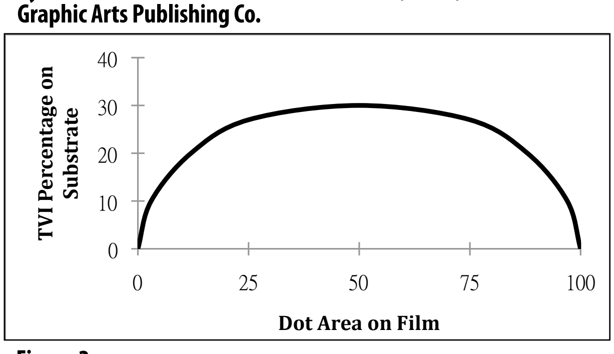


Figure 2.

Print Contrast

Print contrast, an indicator to judge the tones in shadows, also interprets the relationship between SID and TVI. The higher the print contrast, the clearer the tone. Print contrast is the measurement of contrast in shadows, or the extent to which a viewer can distinguish different densities in shadows of a printed substrate. In other words, print contrast is a key indicator in judging how well shadow detail is held on a printed substrate. Print contrast is calculated using the density of a solid color block and the density of a 75% block (75% or 80%) of the same color (Fenster, 1999, p. 35). The equation is as follows:

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

(D_S: Density of a solid color block [including density of the paper].
D_t: Density of a 75% block [including density of the paper]).

Print contrast is one of the most useful print attributes in measuring print quality because print and color separation technicians consider it a main indicator in judging how good the tone is in image reproduction, while customers also regard it as a standard for judging printing quality (Fenster, 1999, p. 35). The higher the print contrast, the greater the shadow details are. Print contrast is subject to SID, brightness of substrate, density of 75% block, and gloss. TVI may cause print contrast loss in color printing and yield printed products with dark tones and color change (Southworth M. & Southworth D., 1989, Ch. 14–13). During printing processes, the printing craftsman should adjust settings and try to get the greatest possible print contrast because the higher the print contrast the greater the details between 75% block and SID (DeJidas & Destree, 1995, p. 51).

Ink Trapping

The adhesion between ink and paper is usually better than that between the first down ink and the overprinting ink. Ink trapping is the ability of the first down ink to get hold of the overprinting ink. The better the ink trapping, the greater the thickness of overprinting ink film, and the better the color gamut. If overprinting ink is printed when the first down ink is dry, it is wet-on-dry printing; otherwise, it is wet-on-wet printing. Many equations can be used in calculating ink trapping. The most commonly used (Tritton, 1997, p. 115) equation is:

$$\text{Ink Trapping (\%)} = \frac{D_{1+2} - D_1}{D_2} \times 100.$$

(D_{1+2}: density of multiple-ink patch, D_1: density of the first down ink, D_2: density of the overprinting ink.)

Grayness

Grayness indicates the percentage of gray in single color layers of cyan, magenta, and yellow. The lower the grayness, the purer the ink is. When process color printing, it is desirable to use ink with a lower grayness value in order to get a better color gamut (Brehm, 1992). Listed hereunder is the equation for grayness calculation:

$$\text{Grayness (\%)} = \frac{L}{H} \times 100.$$

(H: the highest density obtained with C/M/Y filter.
L: the lowest density obtained with C/M/Y filter.)

Hue Error

There are two types of hue error: process color hue error and overprint color hue error. Process color hue error can be used in determining the purity of a single color ink while overprint color hue error is for judging how good the overprint color is. The equation for hue error calculation is listed below:

$$\text{Hue Error (\%)} = \frac{M-L}{H-L} \times 100.$$

(H: the highest density obtained with C/M/Y filters.
M: the mean density obtained with C/M/Y filters.
L: the lowest density obtained with C/M/Y filters.)

1. Process color hue error: Density of primary ink measured with C/M/Y filters. The lower the density, other than that of the primary color, the purer the ink. Or, the closer the mean density to the lowest density, the lower the hue error value, and the purer the ink.
2. Overprint color hue error: Density of overprint ink measured with C/M/Y filters. The lower the density, other than that of the main color, the better the overprint ink. Or, the closer the mean density to the lowest density, the lower the hue error value, and the better the overprint ink (Brehm, 1992).

Research Methods

Research Design

Based on true experimental methods, this study explores variations in print attributes among different combinations of hybrid screening technologies of offset lithography on matte-finish paper to determine the optimal FM-AM-FM hybrid screening combination through experimental validation.

Research Variables

Variables in this study were:

Dependent variables:

1. Tone value increase;
2. print contrast;
3. ink trapping;
4. hue error; and
5. grayness.

Independent variables:

Eleven different hybrid (FM-AM-FM; highlight-midtone-shadow) screening combinations.

Measuring Instruments

A GretagMacbeth Eye-One iO Reflective Spectrophotometer was used in this study for automation of measurement and reading the density of color blocks in the test form. This study measured of K, C, M, and Y densities of dot area at 5%, 10%, 15%, 20%, 25%, 30%, 40%, 50%, 60%, 70%, 75%, 80%, 85%, 90%, 95% and 100%, and densities of R, G, and B.

Printed sheets with different percentage combinations of hybrid screening were selected by systematic random sampling for measurement. Each sample was measured by a GretagMacbeth Eye-One iO for densities of K, C, M, and Y four colors at solid ink, highlights, shadows, and midtones as well as R, G, and B solid densities. Based on densities obtained, various print attributes of dot area, tone value increase, print contrast, ink trapping, hue error, and grayness were calculated with appropriate equations set in Microsoft Excel. All data were collected and recorded for follow-up analyses.

Data collected and recorded were then analyzed with statistical software to establish print attribute standards for different screening technologies. Statistical analysis methods used in this study include descriptive statistics and one-way analysis of variance.

Experiment Procedures

1. Design of the test form for the experiments.

Flow Chart of the Experiments

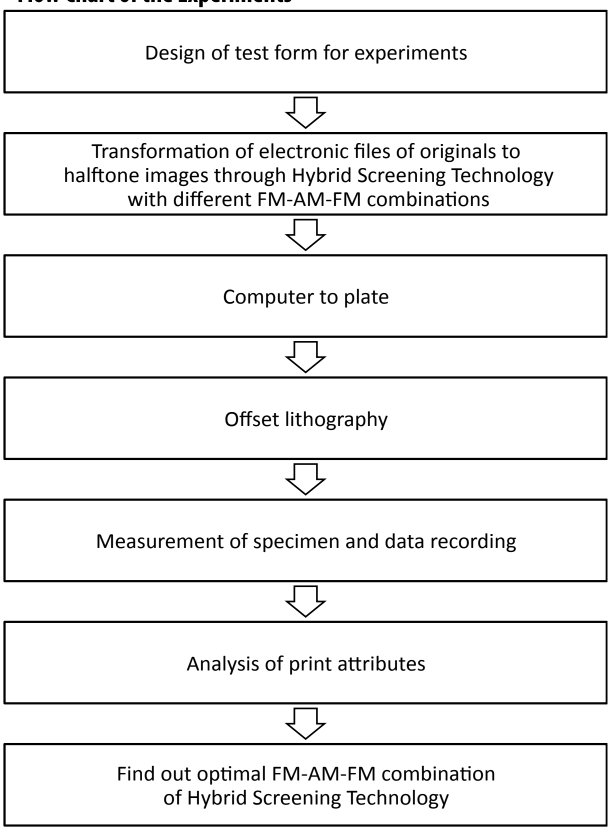


Figure 3

Image of the digital test form used in this study.

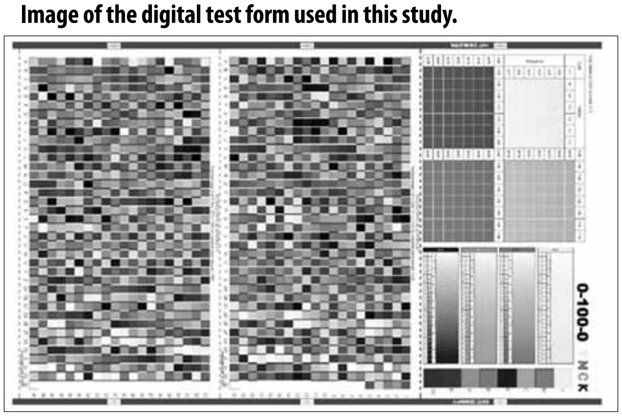


Figure 4

Explanation of the digital test form used in this study.

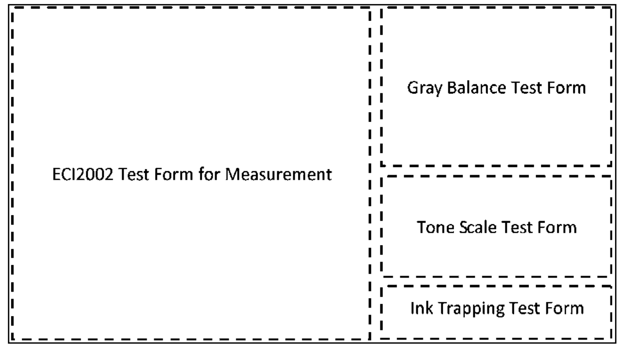


Figure 5

Shown in Figure 4 is the test form used in this study with reference to the GATF Digital Test Form 5.0 for color quality standards and property analysis. Based on ECI2002R (at random sequence) for measurement, the test form used in this study has a format of 28×45 (cm). Refer to Figure 5 for an explanation of the test form.

2. Combinations of hybrid screening technology.

   FM screening technology is used at highlights and shadows in this study (say, a% and c% respectively) and AM screening technology is used at midtones (say, b%). Since grayscale varies from black at 100% to white at 0%, a + b + c = 100. As shown in Figure 6, percentage of AM for midtones is set at b%. Due to the fact that, for printed substrates, any tone variation less than 5% cannot be distinguished with naked eyes, an interval of 5% was set in this study. Eleven different hybrid (FM-AM-FM; highlight-midtone-shadow) screening combinations are shown in Table 2.

Hybrid screening technology combination

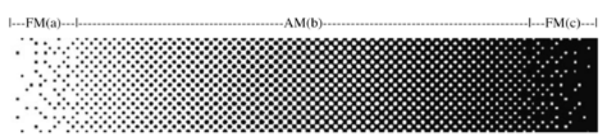


Figure 6

3. Computer to plate.

   The original test form for the experiments was output for plate-making via computer to plate. Six sets of four-color (C, M, Y, K) printing plates were output at175 LPI.

4. Properties and conditions of printing plates, ink and paper used in printing.

Table 2: Eleven hybrid screening technology combinations used in this study.

Combination	a+b+c=100		
	a	b	c
1	5	80	15
2	5	85	10
3	5	90	5
4	10	70	20
5	10	75	15
6	10	80	10
7	10	85	5
8	15	70	15
9	15	75	10
10	15	80	5
11	20	70	10
	Total of 11 combinations		

Plate Properties: The brand name of printing plate used in this study was Horsell Elextra Excel HRL-Thermal Plate, thickness of 0.3μ.

Plate Setting: Exposure, dryer, and light finisher used for CTP in this study were Creo Lotem 800 II Quantum, with acid bath at 20°C, LPI of 175, exposure for 90 seconds. Wash-out machine was W-PTP-45C with 40 seconds wash-out, at a baking temperature at 60°C.

Ink Conditions: The ink used in printing in this study was Soy-CERVOat 25°C.

Print substrate: Matt finish paper used in this study was 150 pound coated paper.

Printing Press Conditions: The printing machine used in this study was a Heidelberg X-TRACSTAR 102-IR. The blanket was made by Böttcher. The paper feeding system in the printing machine is equipped with a roller feeder at a speed of 10,000 sheets/hour. The drying system is infrared. The temperature of the printing house was set at 23°C with relative humidity of 69%.

5. Printing

   Offset lithographic processes and conditions thereof were conducted and set according to GRACoL (General Requirements for Applications in Commercial Offset Lithography) formulated by the IDEAlliance International Prepress Association (IPA), and GATF. Before the actual printing, a trial run was conducted for SID to reach the standard stipulated in GRACoL. The ideal SID's are K (1.70), C (1.40), M (1.50), and Y(1.05).

6. Sampling of prints

   Since densities used in the local printing industry conform to conditions set forth in GRACoL (jointly stipulated IDEAlliance, IPA, and GATF), SID were therefore changed to K(1.70), C(1.40), M(1.50) and Y(1.05) accordingly.

Systematic random sampling was conducted on 100 copies of printed sheets printed with each set of printing plates. Considering possible uneven ink spreading, the first and the last 10 copies were removed and 40 copies were sampled from the remaining 80 copies. First, the 80 copies were labelled in order from 1–80. Since the interval is 80 (total number in the population) divided by 40 (number of samples), this study took one sample every two copies. Based on a simple random sampling, a number from 1–80 is selected as the start, and then one sample is selected every two copies after that. Densities of K, C, M, and Y at solid ink, highlights, shadows, and midtones, as well as R, G, and B densities of the 40 samples were measured with a GretagMacbeth Eye-One iO reflective spectrophotometer. Based on the densities obtained, various print attributes of dot area, tone value increase, print contrast, ink trapping, hue error, and grayness were calculated with appropriate equations set in Microsoft Excel. Data were then input to statistical software for finding the optimum combination through calculation and analysis.

Results and Discussion

Descriptive Statistics

Descriptive statistical data of dot area, tone value increase, print contrast, ink trapping, hue error, and grayness of each combination were compiled for comparison and analyses. Listed in Table 3 are data from the 11 combinations. All data were rounded up to two decimal points.

Hypothesis Testing

The TVI of K, C, M, and Y of each combination was analyzed to find out whether there is a significant difference between different percentage combinations of hybrid screening print attributes on matte-finish paper

Table 3: Descriptive statistical data of the 11 hybrid combinations used in this study.

Combination		5-80-15	5-85-10	5-90-5	10-70-20	10-75-15	10-80-10
Ink trapping (%)	R(MY)	1.2433	1.3330	1.2790	1.3713	1.3112	1.3713
	G(CY)	1.6268	1.6495	1.5833	1.6158	1.54225	1.5973
	B(CM)	1.3835	1.3938	1.3763	1.3730	1.3538	1.4608
Print contrast (%)	C	1.6373	1.6280	1.6460	1.6240	1.6205	.6268
	M	68.182%	67.442%	70.168%	68.158%	69.648%	68.402%
	Y	91.167%	90.262%	90.075%	90.727%	90.165%	89.676%
	K	81.810%	78.214%	83.674%	78.437%	79.092%	78.692%
Hue error	C	37.983%	40.487%	37.710%	40.965%	1.3112%	41.756%
	M	40.586%	40.63%	41.094%	41.804%	1.54225%	39.468%
	Y	25.767%	25.041%	27.926%	31.644%	1.3538%	25.208%
Grayness	C	40.745%	40.888%	42.079%	42.501%	1.6205%	40.34%
	M	13.050%	12.711%	10.566%	12.636%	12.636%	12.750%
	Y	41.024%	40.819%	41.061%	40.655%	40.655%	40.888%
50% TVI	C	3.693%	3.745%	4.489%	3.713%	3.713%	3.732%
	M	14.016%	14.273%	15.991%	14.293%	14.892%	14.324%
	Y	7.744%	7.867%	9.348%	8.047%	9.354%	8.078%
	K	1.173%	1.326%	2.052%	1.439%	1.284%	1.318%

Combination		10-85-5	15-70-15	15-75-10	15-80-5	20-70-10
Ink trapping (%)	R(MY)	1.3370	1.4063	1.3268	1.3948	1.3723
	G(CY)	1.5758	1.5120	1.5600	1.5500	1.5683
	B(CM)	1.3925	1.4758	1.4235	1.4590	1.3538
Print contrast (%)	C	1.7105	1.7138	1.6295	1.7055	1.618
	M	70.161%	80.14%	68.998%	69.031%	70.129%
	Y	91.533%	87.80%	89.850%	87.997%	91.529%
	K	79.231%	71.97%	81.895%	78.484%	79.022%
Hue error	C	40.092%	41.299%	39.610%	43.499%	43.337%
	M	40.430%	39.536%	39.647%	42.741%	44.662%
	Y	22.570%	22.750%	26.122%	32.509%	32.702%
Grayness	C	38.480%	39.126%	37.812%	44.032%	45.95%
	M	12.817%	10.610%	10.606%	12.762%	13.031%
	Y	41.696%	41.167%	41.099%	40.267%	40.641%
50% TVI	C	4.039%	4.430%	4.538%	3.509%	3.672%
	M	14.866%	16.203%	15.397%	14.179%	14.028%
	Y	7.664%	92.79%	9.123%	7.870%	7.779%
	K	0.845%	1.711%	1.703%	1.354%	1.423%

Table 4: 50% TVI in 11 hybrid combinations of offset lithography within 95% confidence interval.									
Hybrid Combinations	K50%	Ranking	C50%	Ranking	M50%	Ranking	Y50%	Ranking	Total Ranking
5-80-15(A)	24.23±0.23	4	20.30±0.23	6	23.05±0.20	8	29.48±0.24	6	24
5-85-10(B)	23.38±0.17	3	19.68±0.20	5	23.07±0.18	8	29.63±0.20	6	22
5-90-5 (C)	24.66±0.23	4	20.82±0.17	8	22.59±0.29	7	28.75±0.18	5	24
10-70-20(D)	23.89±0.18	4	20.15±0.22	6	21.42±0.21	4	27.86±0.15	4	18
10-75-15(E)	21.65±0.19	1	18.04±0.15	1	19.98±0.23	2	26.13±0.32	2	6
10-80-10(F)	24.51±0.17	4	20.76±0.22	8	23.37±0.20	8	29.61±0.17	6	26
10-85-5 (G)	26.07±0.33	9	19.59±0.28	4	22.05±0.19	5	32.45±0.31	11	29
15-70-15(H)	26.76±0.22	11	20.84±0.29	8	22.29±0.29	5	31.70±0.13	10	34
15-75-10(I)	26.04±0.3	9	21.01±0.36	8	24.26±0.37	11	30.20±0.21	9	13
15-80-5 (J)	24.01±0.12	4	19.25±0.21	3	21.13±0.20	3	27.06±0.19	3	13
20-70-10(K)	21.74±0.23	1	18.90±0.17	2	19.27±0.21	1	24.90±0.21	1	5

with output from the same original, printed by the same offset lithographic machine, and measured by the same instrument. A smaller ranking number indicates superiority. If the same data were obtained under analysis within 95% confidence interval, the same ranking was given. All data are rounded up to two decimal points. The cell with shading in the table indicates the optimum combination. Graphic analysis confirms that no deviation from normal distribution was exhibited by any of the eleven combinations and tolerance of data were calculated within 95% confidence interval.

Data of 50% TVI of 11 hybrid combinations of offset lithography are listed in Table 4. TVI is the enlargement of dot area during printing processes, which can be classified to physical increase and optical increase. The smaller the TVI, the better the result is. Judging from the table, the combination of 20-70-10 (K) is the superior one.

Data of average R, G, and B ink trapping of the 11 hybrid combinations are listed in Table 5. The ink trapping data indicate the color gamut from solid ink of either two of C, M, and Y to form R, G, or B. The bigger the number, the better. Judging from the table, the combination of 5-90-5 (C) is the superior one.

Table 5: Data of average R, G, B ink trapping in the 11 hybrid combinations within 95% confidence interval.							
Hybrid Combinations	R (MY)	Ranking	G (YC)	Ranking	B (CM)	Ranking	Total Ranking
5-80-15(A)	68.18±0.35	2	91.17±0.70	1	81.81±0.37	2	5
5-85-10(B)	67.44±0.36	2	90.26±0.32	1	78.21±0.37	5	8
5-90-5 (C)	70.17±0.73	2	90.08±1.11	1	83.67±0.62	1	4
10-70-20(D)	68.16±0.31	2	90.73±0.73	1	78.44±0.30	5	8
10-75-15(E)	69.65±0.44	2	90.17±0.32	1	79.09±0.28	5	8
10-80-10(F)	68.40±0.56	2	89.68±0.67	1	78.69±0.53	5	8
10-85-5 (G)	70.16±0.74	2	91.53±0.75	1	79.23±1.29	5	8
15-70-15(H)	80.14±0.87	1	87.80±0.72	1	71.97±0.77	4	6
15-75-10(I)	69.00±0.41	2	89.85±0.55	1	81.90±0.51	2	5
15-80-5 (J)	69.03±0.33	2	88.00±0.31	11	78.48±0.27	5	18
20-70-10(K)	70.13±0.37	2	91.53±0.37	1	79.02±0.32	5	8z

Table 6: Data of average K, C, M, Y print contrast in the 11 hybrid combinations within 95% confidence interval.

Hybrid Combinations	K	Ranking	C	Ranking	M	Ranking	Y	Ranking	Total Ranking
5-80-15(A)	40.75±0.28	6	37.98±0.21	10	40.59±0.19	5	25.77±0.27	6	27
5-85-10(B)	40.89±0.27	6	40.49±0.25	6	40.63±0.23	5	25.04±0.28	6	23
5-90-5 (C)	42.08±0.33	4	37.71±0.31	10	41.09±0.32	5	27.93±0.40	5	24
10-70-20(D)	42.50±0.25	4	40.97±0.18	6	41.80±0.20	4	31.64±0.20	1	15
10-75-15(E)	1.62±0.25	1	1.31±0.18	1	1.54±0.24	2	1.35±0.29	1	5
10-80-10(F)	40.34±0.21	8	41.76±0.21	4	39.47±0.25	9	25.21±0.45	6	27
10-85-5 (G)	38.48±0.62	9	40.09±0.82	8	40.43±0.95	5	22.57±0.63	10	32
15-70-15(H)	39.13±0.62	9	41.30±0.36	4	39.54±0.33	9	22.75±0.34	10	32
15-75-10(I)	37.81±0.16	11	39.61±0.47	8	39.65±0.53	9	26.12±0.34	6	34
15-80-5 (J)	44.03±0.23	3	43.50±0.05	1	42.74±0.21	3	32.51±0.29	1	8
20-70-10(K)	45.95±0.17	1	43.34±0.21	1	44.66±0.24	1	32.70±0.22	1	4

Data of average K, C, M and Y print contrast of the 11 hybrid combinations are listed in Table 6. Print contrast indicates how well details in shadows are held in a print. The higher the print contrast, the greater the shadow details. Judging from the table, the hybrid combination of 20-70-10 (K) is the superior one.

Data of average C, M, and Y hue errors of the 11 hybrid combinations are listed in Table 7. Hue error is color deviation of C, M, and Y inks. The smaller the hue error, the better. Judging from the table, the Hybrid Combination of 15-80-5 (J) is the superior one.

Data of average C, M, and Y grayness in the 11 hybrid combinations are listed in Table 8. Smaller grayness trans-

Table 7: Data of average C, M, Y hue errors in the 11 hybrid combinations within 95% confidence interval.

Hybrid Combinations	Cyan (C)	Ranking	Magenta (M)	Ranking	Yellow (Y)	Ranking	Total Ranking
5-80-15(A)	13.05±0.10	5	41.02±0.12	1	3.69±0.09	2	8
5-85-10(B)	12.71±0.13	5	40.82±0.18	1	3.75±0.08	2	8
5-90-5 (C)	10.57±0.14	2	41.06±0.14	1	4.49±0.06	8	11
10-70-20(D)	12.64±0.12	5	40.66±0.11	1	3.71±0.04	2	8
10-75-15(E)	12.64±0.33	1	40.66±0.15	1	3.71±0.11	8	10
10-80-10(F)	12.75±0.12	5	40.89±0.15	1	3.73±0.12	2	8
10-85-5 (G)	12.82±0.16	5	41.70±0.50	2	4.04±0.13	7	14
15-70-15(H)	10.61±0.13	2	41.17±0.23	1	4.43±0.11	8	11
15-75-10(I)	10.61±0.13	2	41.10±0.22	1	4.54±0.11	8	11
15-80-5 (J)	12.76±0.12	5	40.27±0.16	1	3.51±0.05	1	4
20-70-10(K)	13.03±0.13	5	40.64±0.14	1	3.67±0.07	2	8

Table 8: Data of average C, M, Y grayness in the eleven hybrid combinations within 95% confidence interval.							
Hybrid Combinations	Cyan (C)	Ranking	Magenta (M)	Ranking	Yellow (Y)	Ranking	Total Ranking
5-80-15(A)	14.02±0.15	1	0.74±0.10	1	1.17±0.13	2	4
5-85-10(B)	14.27±0.06	1	7.87±0.04	1	1.33±0.08	2	4
5-90-5 (C)	15.99±0.17	7	9.35±0.09	8	2.05±0.12	11	26
10-70-20(D)	14.29±0.10	1	8.05±0.03	1	1.44±0.04	2	4
10-75-15(E)	14.89±0.15	7	9.35±0.14	8	1.28±0.11	2	17
10-80-10(F)	14.32±0.11	1	8.08±0.08	1	1.32±0.08	2	4
10-85-5 (G)	14.87±0.21	10	7.66±0.15	1	0.85±0.09	1	12
15-70-15(H)	16.20±0.15	11	92.79±0.12	8	1.71±0.11	9	28
15-75-10(I)	15.40±0.24	9	9.12±0.21	8	1.70±0.22	9	26
15-80-5 (J)	14.18±0.10	1	7.87±0.07	1	1.35±0.04	2	4
20-70-10(K)	14.03±0.10	1	7.78±0.08	1	1.42±0.07	2	4

lates into higher ink purity of the ink. The smaller the grayness, the better. Judging from the table, the hybrid combination of 5-80-15 (A), 5-85-10 (B), 10-70-20 (D), 10-80-10(F), 15-80-5 (J), 20-70-10 (K) are the superior ones.

Identifying the Optimum Hybrid Combination

Eleven hybrid combinations were designed in this study and relevant print attributes (dot area, tone value increase, ink trapping, print contrast, hue error, and grayness) of the printed sheets thereof were measured and recorded. Data from the 11 hybrid combinations were statistically analyzed to find out the optimum hybrid combination in terms of 50% TVI, ink trapping, print contrast, hue error and grayness. Finally, the overall optimum hybrid combination was identified by adding up ranking numbers in each print attribute. Scores and ranking of each print attribute are listed in Table 9. Through hypothesis testing and analyses, the hybrid combination

Table 9: Overall scores and ranking of 11 hybrid combinations of offset lithography on matte paper.							
Hybrid Combinations	Tone value increase	Ink trapping	Print contrast	Hue error	Grayness	Total Score	Ranking
5-80-15(A)	24	5	27	8	4	68	6
5-85-10(B)	22	8	23	8	4	65	5
5-90-5 (C)	24	4	24	11	26	89	8
10-70-20(D)	18	8	15	8	4	53	4
10-75-15(E)	6	8	5	10	17	46	2
10-80-10(F)	26	8	27	8	4	73	7
10-85-5 (G)	29	8	32	14	12	95	10
15-70-15(H)	34	6	32	11	28	111	11
15-75-10(I)	13	5	34	11	26	89	8
15-80-5 (J)	13	18	8	4	4	47	3
20-70-10(K)	5	8	4	8	4	29	1

of 10-70-20 (combination K), with the least sum of ranking numbers, is the best among all combinations. In terms of general print attributes, the eleven combinations are ranked as K >E >J >D >B >A >F >C =I >G >H.

Conclusions and Suggestions

Based on offset lithography matte-finish paper printed with different hybrid combinations process, this study analyzed various print attributes and color properties and identified the optimal combination. The measurements of every combination in terms of each print attribute were analyzed and discussed.

Results and Applications

Results of this study show that the hybrid combination of FM-AM-FM is 20-70-10 (K); that is, the use of FM at highlights from 0%~20%, use of AM at midtones from 21%~90% and the use of FM again at shadows from 91%~100%; exhibits fair average performance in most print attributes and demonstrates outstanding performance in print contrast. With a total score of 29, this hybrid combination stands out as the best among all combinations. The hybrid combination of 10-75-15 (F), with similar figures, is identified as the second best combination. These two combinations are suggested to local academic and industrial circles. The two other combinations of 15-70-15 (H) and 10-85-5 (G), with total scores as high as 111 and 95, are the least suitable ones for offset lithography. The optimum combinations in terms of each print attribute are listed in Table 10.

Table 10: The optimum combinations in terms of different print attribute.

Print Attributes	Optimal combination under that print attribute
Tone Value Increase	20-70-10 (K)
Print Contrast	20-70-10 (K)
Ink Trapping	5-90-5 (C)
Hue Error	15-80-5 (J)
Grayness	5-80-15 (A), 5-85-10 (B), 10-70-20 (D), 10-80-10(F), 15-80-5 (J), 20-70-10 (K)

With customers getting more and more demanding for print quality, the improvement of quality and process efficiency have become pressing issues to the printing industry. Based on in-depth research on various print attributes of offset lithography matte finish paper integrated with CTP process, this study identifies and proposes optimum hybrid combinations. It is anticipated that such findings will be helpful to the printing industry in the enhancement of quality, efficiency, and customer satisfaction.

Suggestions to Follow-Up Studies

1. Due to limitations of time and manpower, only one printing substrate is covered in this study. It is suggested that follow-up studies include more substrates.
2. More extensive analyses can be conducted on the comparison between the optimum hybrid combinations discovered by this study and printed sheets with AM and/or FM Screening Technology in terms of print attributes. It is suggested that follow-up studies conduct more research among these three technologies to establish standards of hybrid screening offset lithography.
3. Due to limitations of time and manpower, experiments of the print attributes of hybrid screening technology conducted by this study cover offset lithography plates only. It is suggested that follow-up studies conduct more research on other printing processes, such as flexography, to find out optimum hybrid combinations thereof and compare with our findings for offset lithography.

References

Chuck Surprise (2003). *Flexo CtP Developments Announced by Creo.* Retrieved October 13, 2003, from http: http://www.printondemand.com/MT/archives/001522.html

Color Reproduction. (1996), QMS, Inc. Retrieved November 26, 2005, from http://www.tu-harburg.de/rzt/tuinfo/periph/drucker/Color_Reproduktion/

Dan Blondal (2003). The Lithographic Impact of Microdot Halftone Screening. *TAGA Proceedings 2003,* p. 608.

IDEAlliance (2007). *General Requirements for Applications in Commercial Offset Lithography.* (2007). Guidelines & Specifications.

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The Wired Workforce
Hiring Trends of the Printing Industry

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Introduction

Fueled by the rapid development in Information Technology, publishing technology has developed significantly over the past 20 years. As one result of this, commercial printers have been diversifying into value added services (Davis, 2008). Value added services include: Variable Data Printing (VDP), Graphic Design, Web Site Design, Digital Asset Management (DAM), and Database and Direct Marketing services.

The purpose of this research is to assess the changing workforce requirements in the printing industry due to the changes mentioned above. Value added services provide an opportunity for printers; however, they require a new set of skills in the workforce that could be labeled the *"wired workforce."* A company's ability to expand into digital services is dependent on the skill sets of their employees. In today's economy, how are printing firms adjusting their hiring practices to bring in the new *"wired workforce?"*

New Skill Sets for Wired Workforce

As educators in the field of Graphic Communications, it is important to assess the demand for graduates of our programs. Successful programs will produce graduates who will help transform the US Printing Industry for growth in the 21st century. In order for this to happen, educators need to ensure that the curricula reflect the emerging skill sets required to enable this transformation.

More and more printers are becoming involved in digital services and are integrating different equipment and software into their value-streams. Professor Frank Romano's 2007 article entitled *Where have all the students gone?* identifies the need for incorporating the Internet into every facet of a printing business that requires hiring employees with new skills in these companies (Romano, 2007). In order to do this, they must find employees with skills in information technology, database management, Java scripting, and digital asset management. In a related 2008 article called *The New Printing Workforce*, Romano concluded that the printing industry had a skills shortage of IT-based employees (Romano, 2008).

As documented by Professor Franziska Frey and Henrik Christensen in their 2005 survey of hiring trends for digital asset management (DAM) and variable data printing (VDP) services, fewer than 10% of employees hired by digital printing services firms were in information systems, networking, or database management for VDP and DAM (Frey and Christensen, 2006). The majority of companies (83%) provided DAM and VDP training in-house with the top training areas in spreadsheets (41%) and VDP applications (34%).

Training for Digital Skills

As printing companies require more digital skills within the workforce, many progressive firms are retraining employees in desired job skills. However, they find that in some instances, there is ambiguity as to what digital functions are required within the company. Howie Fenton from Graphic Arts Online states that *"About one quarter of all new hiring in the printing industry involves IT-based functions. Some printers do not always define these skill sets as IT-based. Industry needs to provide a long-term action plan; enterprises must promote solutions within the workplace; and education/training providers must broaden their approaches to traditional training"* (Fenton, 2008).

Research Objective

The purpose of this research was to describe the changing workforce requirements in the printing industry. Using Printing Industry Center research by Frey and Christensen published in 2006 as a benchmark, this research determined changes in the nature and number of employees hired or being sought by printing services providers. In addition, the research investigated the types of digital services companies offer, as well as the amount of training dollars allocated to digital services skills for existing employees. Lastly, with the inclusion in the sample of both digital printers, and primarily offset printers, the differences in hiring by the focus of the firm were also examined.

Questionnaire

Survey questions from Frey and Christensen's *New Skills for DAM and Variable Data Printing Services: Is the Printing Industry Prepared?* were utilized in order to gather data for the comparative analysis. These questions included:

- *Company demographics:* The location, size, revenue, and services offered.

- *Skill sets and hiring practices:* conventional and digital services personnel that firms have employed or are currently seeking.
- *Training practices:* amount spent on total training and percent of total spent on digital services.
- *Workforce hiring plans.*

Procedure

The data were gathered using an online survey of printers conducted in November 2008. A link to the survey was distributed by email to a list of printers provided by NAPCO, the North American Publishing Company, publisher of *Printing Impressions, Package Printing, In-Plant Graphics,* and *Print Professional* magazines. As an incentive to complete the survey, respondents had the option to choose one of three *InfoTrends* reports free of charge. The respondents also had the option to participate to a follow-up phone/e-mail interview to help clarify responses. There were approximately 43,000 printers that were emailed the request to participate and 195 firms completed the survey yielding a 0.45% response rate. The standard error of a proportion for this sample size is 0.036 which yielded a 95% confidence interval of +/- 7% for the results reported as percentages.

Results

Company Size

Company size was measured in two ways: by number of employees and by revenue for 2007. The average number of employees in all production facilities was 54.7 (the median was 22.5). Company's revenues from 2007 fiscal year were consolidated into three main categories. Half of the respondents earned less than $3 million, 25% earned between $3 and $10 million, and 25% earned over $10 million.

Table 1: Hiring by job function *n*=195

Job Function	Percent of Total Employees	Percent of firms that hired at least one employee in job function*
Finishing, Mailing, & Fulfillment	26%	34%
Customer Service/ Sales	25%	57%
Printing press operations	20%	37%
Prepress	9%	32%
IT	6%	18%
Production Management	5%	21%
Digital services	5%	18%
Estimating & Planning	4%	19%

*Adds to over 100% due to multiple responses

Table 2: Skill sets printers are currently seeking *n*=195

Skill Sets	Percentage of Firms Currently Seeking
Customer service/Sales	14%
Mailing	8%
VDP set-up/operation	6%
Finishing	6%
Binding	6%
Database & direct marketing set-up/orientation	5%
Digital press operator	5%
Fulfillment	5%
Production workflow	5%
Interactive media manager/specialist	4%
Graphic design	4%
IT – Administration	4%
DAM set-up/maintenance	4%
Conventional press operator	4%
IT – Networking	3%
Color mgmt. set-up/handling/maintenance	3%
XML/Java/PERL/etc	2%
Kitting fulfillment	2%
Computer programming	1%
Photography	0%

Workforce Hiring Trends

The companies surveyed provided information about the number of new employees hired over the past two years. A total of 1209 employees were hired by the responding firms. As shown in Table 1, 26% were in finishing, mailing, and fulfillment, 25% were in customer service and sales, and 20% were in printing press operations. The fewest number of employees hired were in estimating and planning roles (4%) and Information Technology (6%).

The right-most column of Table 1 presents the *percentage of firms* that hired at least one employee in that job function. Over half of the firms had hired customer service and sales employees (57%), and approximately one-third hired printing press operators (37%); finishing, mailing, and fulfillment employees (34%); and prepress employees (32%). Fewer than 20% of firms hired IT or digital service employees.

Companies were asked what skill sets they were seeking in future employees. Table 2 presents the percentage of firms who were currently searching for employees with specific skill sets. The top area was customer service and sales (14%), followed by mailing (8%), VDP set-up and operation (6%) and finishing (6%). The lowest priorities were for computer programming (1%) and photography (0%).

Investment in Training Current Employees

Many firms obtain new capabilities by retraining existing employees in the needed skills. In this survey, the median amount spent on employee training annually was $2,000. The median amount of training per employee was $105.

When asked what percentage of the training dollars were for digital services, firms reported an average of less than 10% was spent on digital services annually.

Table 3: Percentage of companies that invest in specific skills training *n*=195

Job functions companies have provided training to existing employees	Percent of firms who trained
Page layout programs	46%
Color management	42%
PDF workflow	41%
Digital press operation	39%
Mailing	34%
VDP applications	34%
Spreadsheets	32%
Web store front for your own company	23%
Customer database management	21%
IT- Networking	20%
Other	18%
IT- Administration	13%
Customer webpage production	13%
DAM	8%
JDF	8%
XML, Java, PERL	7%

Table 3 presents the percentage of firms who were offering training by skill areas. The most frequently offered training was for page layout programs (46%), color management (42%), and PDF workflow (41%). The lowest frequency was found for XML/ Java/ Perl training (7%), JDF (8%), and DAM (8%).

Within the current U.S. economic downturn, the past hiring practices may not be the norm for the future. Therefore, information was asked about the workforce hiring plans for 2009. The findings were as follows: 59% of the companies plan to keep the workforce the same size, 21% plan to reduce the workforce, and 20% plan to grow the workforce.

Comparing 2005 and 2008

The benchmark data was collected in 2005 and comprised 103 responses sampled from the RIT Printing Industry Center database, which included companies across the United States and Canada. Specifically, those printers that considered themselves digital printers were contacted by phone and participated in a telephone survey. In 2008, a wide range of printers was surveyed, not exclusively digital printers. To create a comparable sample to the 2005 data and to identify the trends between primarily offset versus digital printers, the 2008 sample was split between companies that had low digital printing revenue (0–9% of revenues) and printing firms with 10% or more of revenue from digital printing. The 85 firms that had 9% or less of their revenue from digital printing were labeled *"2008 Offset"* and the 110 firms with over 10% of revenue from digital printing were labeled *"2008 Digital."*

Table 4 presents the percentage of firms who hired at least one employee in each job function. Examining the two right-most columns, there were more similarities than differences between 2005 and 2008 for the digital printers. Specifically, hiring for digital services, customer service, and production management functions, the results were similar for both years. Differences were found in 2008 where fewer digital printers hired employees in printing press operations, prepress and IT than in 2005.

In addition, it is noteworthy how similar the results are in 2008 between the primarily offset versus the digital printing firms. The only exceptions were more production employees were hired by offset firms and more digital services employees were hired by digital firms.

Table 4: Percent of Firms Hiring by Job Function (2005 & 2008)

Job Function	2008 Offset Percent of Firms who hired	2008 Digital Percent of Firms who hired	2005 Digital Percent of Firms who hired
Finishing, Mailing, & Fulfillment	38%	32%	*
Customer Service/ Sales	59%	56%	55% customer service (45% sales)
Printing press operations	43%	33%	48%
Prepress	34%	31%	42%
IT	23%	15%	24%
Production Management	26%	16%	18%
Digital services	12%	24%	22%
Estimating & Planning	21%	17%	21%
n=	195		103

* This category was not included in the 2005 survey.

Training skill sets

One of the key findings from the 2005 research was that 34% of companies provided training in-house in VDP applications and spreadsheets. The 2008 results revealed an increase to 48% of digital printing firms providing VDP training. For spreadsheet training, the trend was reversed: 29% of firms in 2008 provided training versus 41% in 2005. In addition, there were a higher percentage of companies in 2008 offering training in Web store front, PDF workflow, color management, and IT than in 2005.

Discussion

The major finding of this research is that there remains a substantial demand for digital services employees by printing firms. Examining the percentage of firms hiring, 22% of digital printers hired employees in digital services in 2005 versus 24% in 2008. In addition, the hiring of IT employees was approximately the same for both years (16% and 18% of firms). It was noted that approximately one-third of the printers hired mailing and fulfillment employees. This is the first step toward becoming a marketing services provider and should be seen as a good sign that the industry is acknowledging this.

The other way firms acquire digital service expertise is training existing employees in new job skill areas. The areas of training of existing employees showed some differences between 2005 and 2008. In 2005, the most frequently observed areas of training were for spreadsheets and VDP applications at 41% and 34% respectively. Though training on spreadsheets decreased in 2008, VDP applications training had increased where nearly half of digital firms reported training their employees in these skills.

Though these results show an increase in training of existing employees in a number of skill areas, the absolute amount of investment in training is quite low. On average, only $105 per employee was spent on training in 2008. Moreover, less than 10% of that training allotment was spent on digital services. So, while we have good news on the increase in number of firms who trained employees on VDP, the bad news is that the training budgets are still very low.

In sum, the expansion of digital services across all types of printing firms has maintained a steady need for employees with these skills. Printers are adding new employees and retraining existing employees with a primary emphasis in variable data printing. Employment gains in these job functions may be a result of the success that printers are having with providing the full-range of services to deliver personalized marketing campaigns. The other major digital service, digital asset management is not receiving as much attention.

An interesting future lies ahead for the graphic communications industry and the schools affiliated with this industry. Universities should be thinking five to ten years ahead so that curricula encompass current and future capabilities for success. As printing firms are making the transition to become digital services providers, they will require a continuing stream of potential employees who can help them lead the charge.

References

Davis, R. and Gleeson, E. (2008, January). *Printers' Diversification into Ancillary Services.* PIA/GATF Economics and Market Research Department.

Fenton, H. (2008, December 12). *Functions and skill sets of the digital world.* Message posted to http://www.graphicartsonline.com/blog/Print_Trends/18385-Functions_and_skill_sets_of_the_digital_world.php

Frey, F. S., Ph.D., & Christensen, H. H. (2006, June). *New skills for DAM and variable data printing services is the printing industry prepared?* (Monograph No. PICRM-2005-08). Retrieved February 1, 2009, from Printing

Industry Center at RIT Web site: http://print.rit.edu//?page=item&id=107

Romano, F. (2007, July 13). Where have all the students gone? *What They Think*. Retrieved December 15, 2008, from http://members.whattheythink.com//.cfm

Romano, F. (2008, November 21). The new printing workforce. *What They Think*. Retrieved February 9, 2009, from http://members.whattheythink.com//week-frank-romano-081121.cfm

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Integration of a Color Management System (CMS) within the Graphic Communications Laboratory's Digital Proof/Print Production Workflow

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Abstract

In the graphic communications industry, a workflow represents a schematic illustration that deals with the real time production of goods/services by utilizing patterns of activities enabled by a systematic organization of analog and digital devices. In this scenario, an image and its color are generated through digital input devices (scanners and cameras). The digital information representing the image is stored in a data file and printed by using output devices (digital printers and printing presses). Since different devices create and produce color differently, the challenge is to produce consistent color across the entire workflow. Color Management Systems (CMS) allow users to produce accurate color regardless of device color capacities.

This report represents the outcome of a learning module in the curriculum on analysis of Color Management Workflow (CMW) implementation by using CMS applications in the graphic communications management (GCM) program at the University of Wisconsin-Stout (UW-Stout). Furthermore, the data contained in this report are the result of an experiment that was conducted to confirm (or verify) the known theory in order to gain the greater understanding of the stated subject.

Modern Graphic Communications graduates with technical competencies in color management are, and will be, in greater demand than ever before in one of the largest industries in the United States. The colorimetric data of this experiment led to the conclusion that the application and implementation of color management tools/techniques offers us more flexibility and control over colors and tonal values in reproducing color images within the workflow.

Introduction

University of Wisconsin-Stout (UW-Stout) received a donation of Color Management and Control (CMC) Workflow (proofing/printing) software from CGS Publishing Technologies International, Minneapolis, MN. Other companies also made valuable contributions: X-Rite Corporation, Grand Rapids, MI; IDEAlliance, Inc., Alexandria, VA; Chromix, Inc., Seattle, WA; Alder Technology, Portland, OR; and Data Color Corporation in Lawrenceville, N.J. The CMC workflow applications allow color management activities for digital proofing, printing, device emulation, and device calibration and control, and included on-site training and consulting.

Recently, the university's Graphic Communications Management (GCM) program underwent a revamping with the development of new courses, revision of curriculum, and the addition of a new CMC Laboratory to be used for various lab and research activities as well as experimental projects associated with the GCM curriculum. Additionally, the CMC Lab and the Digital Print Production devices also utilize Creo Spire (Xerox DC-250) and Creo Prinergy Evo (CTP) workflow applications to output (print) the students' work, as well as the commercial print jobs. A total of three workflow applications (CGS-ORIS, CREO SPIRE, and PRINERGY EVO) are currently being used. Integration of the new tools and activities is a major asset to the GCM curriculum at UW-Stout. For the students in the program, being able to experience the workflow for proofing as it happens in the industry and seeing how this contributes to quality work and efficiency will be invaluable.

Managing and controlling color from a wide range of input devices (digital cameras and scanners) to multicolor output devices (digital printers and printing presses) is a major concern for the graphic communications and imaging industries. Accurate or facsimile color control from beginning to end in a printing or imaging process is important for quality output (display or printed). Advancements in science and engineering in recent years allow printing and imaging professionals to apply scientific research methods in the prepress, pressroom, and quality control areas of the industry.

Modern printing technology has evolved from the craft-oriented field to more of a color imaging science. This allowed the industry to control the color between the various devices more accurately than before. Review of numerous reports revealed that the study of color is a science and the optical aspects of color only are quantitatively analyzable and measurable. The human eye perceives color more subjectively. Input (scanners or digital cameras) and output (monitors or printers) devices produce colors differently because they depend on their own color capabilities. The color management system simplifies and improves the reproduction of color images accurately from device to device.

Overview of the Color Management System (CMS)

CMS or Color Management Workflow (CMW) uses a set of hardware tools and software applications working together to create accurate color between various input, display, and output devices. A CMS consists of device profiles (or characterization of devices) which control and document the working performance of the scanner, monitor, or the printer. A device color transformation engine (Color Management [Matching] Module [Method] or CMM) interprets the color data between the scanner, display, and the printer. The gamut compensation mechanism of the CMS addresses differences between the color capabilities of input, display, and output devices. A device independent color space (Profile Connection Space or PCS) allows color transformation from one device-dependent color space to another (see Figure 1). The PCS is based on the spaces derived from the CIE color space. Apple ColorSync supports two of these spaces: L* a* b* and XYZ. The color conversion from device dependent color space to device independent color space is achieved by the use of PCS. Device color characterization files (profiles) pass in and out of the PCS to complete the transformation. The PCS of the CMS is the central hub of the CMS in which a particular color value is considered absolute and not subject to interpretation.

Schematic of PCS of CMS (Courtesy of Adobe Systems, Inc.)

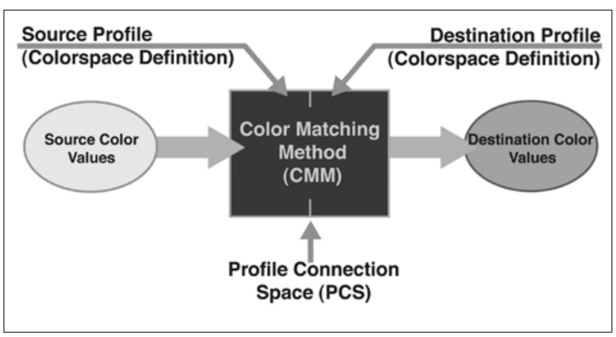

Figure 1

The International Color Consortium (ICC) was formed in 1993 by seven industry members (Adobe, Agfa, Apple, Kodak, Microsoft, Sun Microsystems, and Silicon Graphics) to define the standards for color device characterization (Adams & Weisberg, 2000). Today, ICC represents more than seventy industry and honorary members (ICC, 2009). This device characterization is presented in terms of specially formatted files, which have come to be called profiles. Unfortunately, the use of color management systems has not yet solved all of the problems of color reproduction (Fleming & Sharma, 2002), such as: acceptance of linear colors, reproduction of neutral gray-balance, rendering intents, and so on. However, color management has made possible the quantification of problems. As always in quality control, with quantification comes the ability to control and, with control, quality management becomes possible (Fleming & Sharma, 2002).

The 4 C's (Calibration, Characterization, Conversion, and Control) of CMS or CMW

To implement the CMS successfully, all the devices *(monitor, scanner or digital camera, and printer or printing press)* that are used for printing and imaging purposes must be calibrated, characterized (profiled), and their color capabilities (RGB and CMYK) must be converted into an independent color space (CIE L* a* b* space). A calibration process means standardizing the performance of the devices according to the device manufacturer specifications so that the results of the devices are repeatable.

A profiling process (characterization) refers to the colorimetric assessment of the device color performance and the creation of an ICC (International Color Consortium) profile specific to that device. The characterization process requires CMS hardware tools and software. The characterization of each device is converted into an ICC profile file format. The profile communicates measured color output of devices in response to known output.

Conversion refers to translating a color image data from one device color space to another device space. It is also known as color transformation.

Control (the fourth C) means the user of CMW must monitor and analyze the use of the CMW process through the use of statistical process control (SPC) tools in order to avail the benefits of the CMW.

Purpose and the Limitations of the Research

The experiment focused on the implementation of Color Management Workflow (CMW) in the graphic communications laboratories. Upon implementing the CMW, a clear purpose was established. The purpose was to identify the color differences (CIE L* a* b* values) that exist in the solid color areas of cyan, magenta, yellow, black, red, green, and blue (CMYKRGB) of an image displayed on the monitor vs. printer in a CMW to confirm the known process or CMW standards. Solid color is the attribute that represents overall details (color gamut) of an image.

The image display and print characteristics (ICC profiles) associated with this experiment are characterized by, but not restricted to, inherent limitations. For example: type of digital printer for proofing, type of paper for printing, type of toner, and so on. There are several variables affecting the facsimile reproduction of color images in the CMW and most of them are mutually dependent on each other. The scope of the research was limited to the inkjet digital printing system (printing proof), a liquid crystal display (LCD) monitor (image display), a flatbed scanner (image capturing), and other raw materials and color measuring devices used in the university graphic communications laboratory. Findings were not expected to be generalizable to other CMW environments. The research methodology, experimental design, and statistical analysis were all selected in alignment with the purpose of the research with full awareness of the aforementioned delimitations. It is quite likely, however, others could find the method used and the data of the report meaningful and useful. The prepress and printing laboratory uses color management workflow for accurate color reproduction (see Figure 2).

Schematic of Color Management Workflow at UW-Stout's CMC Lab.

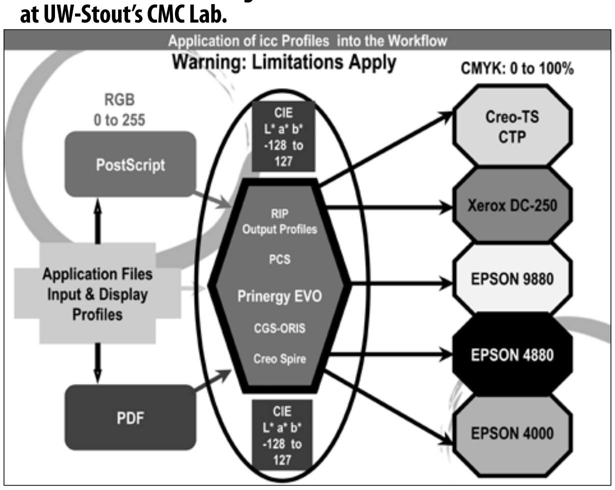

Figure 2

Research Method

This research utilized an empirical research method. It was intended to determine the color differences that exist on the monitor vs. printed proof in a color managed workflow (CMW). A detailed method of this experiment is summarized in the following paragraphs. Prior to device profiling, image capturing, image display, and printing the proof, all devices that were used in the experiment were calibrated and characterized according to device manufacturer standards (specifications or instructions). X-Rite Monaco Profiler software was used to profile or characterize all the devices that were used in the experiment. The profiles used in the experiment were limited to the devices used for the experiment only.

Monitor Profile

An Apple iMac computer's LCD monitor was profiled by using the Monaco OPTIX colorimeter and Monaco Profiler 4.80. The existing default profile of the monitor was disabled in the Macintosh 10.5.2 Operating System (OS) prior to profiling the monitor. The contrast and brightness controls on the monitor were adjusted with the help of the profile making software and were kept the same from the starting point to the end point of the profiling process. This step is also called calibration of the monitor. The desired temperature of 5000 Kelvin (D50), 2° standard observer, and Υ value of 1.80 (the default gamma value for Macintosh OS platforms) were set for the monitor (Sharma, 2004). The new profile was kept active in the OS (see Figure 3).

LCD Monitor Profile.

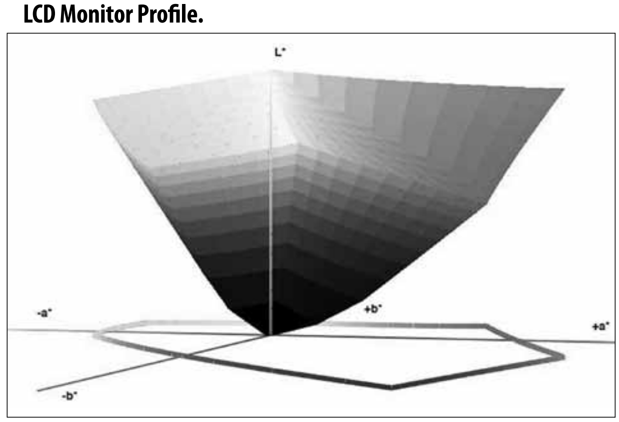

Figure 3

Scanner Profile

The American National Standard Institute/International Standards Organization (ANSI/ISO) Kodak IT8.7/2 scanner target (see Figure 4) was scanned at 200 pixels per inch to create the profile for a Fuji C-550 Lavonia high-end flatbed scanner that was used in the experiment.

Prior to scanning the target, all the color management and color correction options were disabled in the scanner software. Scanner profiling is the process of determining the precise color characteristics of a scanner. To build a scanner profile (see Figure 4), with the use of an IT8.7/2 target, the scanned target was cropped and processed by Monaco Profiler 4.80 software. During the profiling process, the software compared the color data generated by the scanner to TDF (Target Definition File), or the known colorimetric values of the pre-measured target (IT8.7/2 Target Q-60 reference data file) to generate the profile (see Figure 5).

A Kodak ANSI/ISO IT8.7/2 Target for Scanner Profile.

Figure 4

Fuji C-550 High-end Scanner Profile.

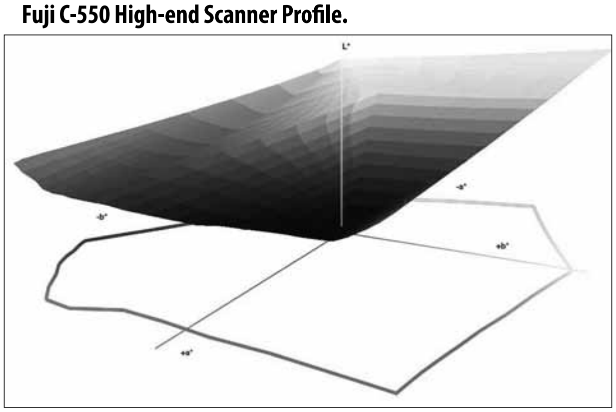

Figure 5

Printer Profile

An ANSI/ISO IT8.7/3 printer target with 917 patches (see Figure 7) was printed on the EPSON Stylus PRO 4880 printer. IT8.7/3 is a printed reflection target that can be used to obtain the color gamut (or color characterization) of a printing device or printer. Prior to printing the patches, the printer was calibrated according to its manufacturer specifications. All the color management and control options were disabled in the RIP (raster image processor) software. Printed patches were measured in CIE L* a* b* space with a X-Rite Eye-One spectrophotometer and the data was processed by the Monaco Profiler 4.80 via X-Rite Color Port to create the printer profile (see Figure 6). Upon completing all these device profiles, they were inspected with ColorThink software for profile accuracy, extracting L* a* b* values and creating profiles L* a* b* graphs.

Epson StylusPRO 4880 Printer Profile.

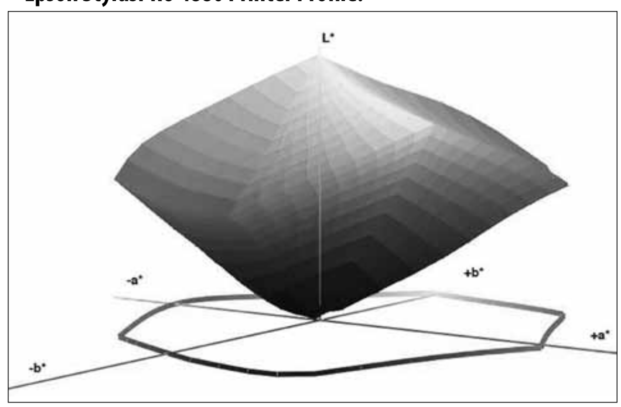

Figure 6

The study successfully created all the device profiles (scanner, monitor and printer) for use in the remainder of the experiment. Visual examinations of all the device profiles indicated that the monitor and printer profiles are smaller than the scanner profile (see Figure 8). Each profile is an indication of different color capabilities because each one represents a different imaging device.

Color gamut mapping can be completed by one of the four ICC recognized colorimetric rendering intents: perceptual, absolute, relative, and saturation. The rendering intent determines how the colors are processed that are present in the source gamut but out of gamut in the destination (output). For this experiment, absolute colorimetric intent was chosen. It intends to produce in-gamut color exactly and clips out-of-gamut colors to the nearest reproducible hue.

ANSI/ISO IT8.7/3 Printer Target (917 Patches), Created by X-Rite Color Port 1.5.3.

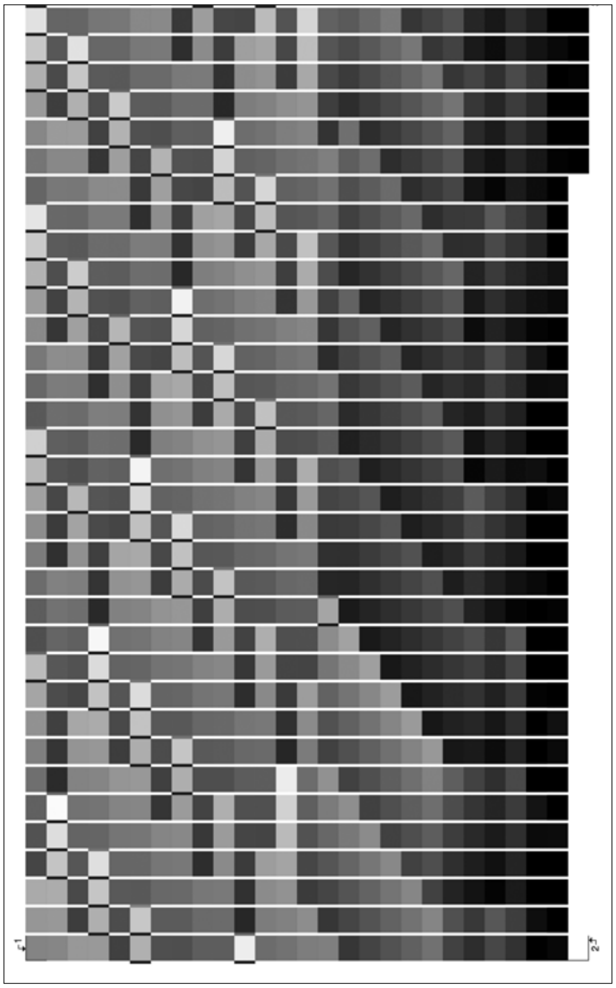

Figure 7

All Device Profiles Comparison in 2D CIE L* a* b* Space

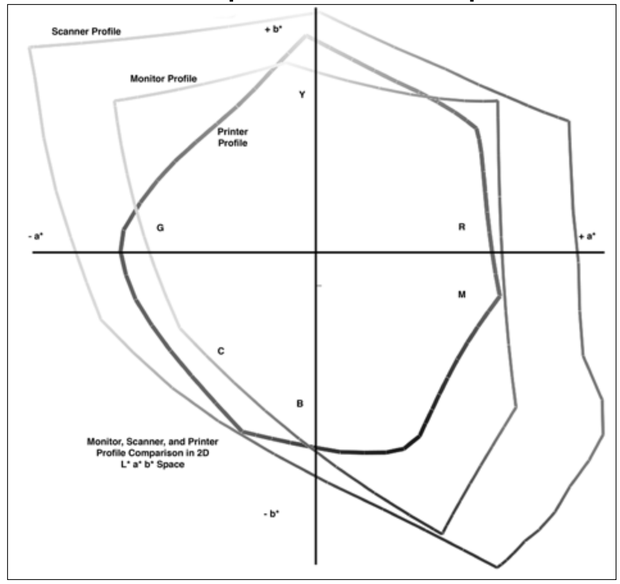

Figure 8

Application of Profiles for Printing

A test image was created for proofing and printing use for the experiment (see Figure 10). The test target contained the following elements: CMYKRGB tone scales and Kodak IT8.7/2 patches for colorimetric data, CMY overprint and neutral gray patches, and an ISO 12647 Control Strip. The scanned test image (IT8.7/2) was opened with Adobe PhotoShop CS-3 and displayed onto the i-Mac's LCD monitor. All the device profiles were embedded (or assigned) to the test image in the Adobe PhotoShop CS-3 application with an absolute colorimetric rendering intent (see Figure 9). The CIE L* a* b* data of an image on the monitor was recorded for later comparison with the printed proof and the image was then saved. Later, the saved image was imported into the page layout program (InDesign CS-3) and a PostScript (PS) file was made. The PS file was rasterized (or ripped) by using CGS-ORIS raster image processor (RIP). The printer profile was attached to the ripped file and the file was sent to the EPSON Stylus PRO 4880 printer to print the proof (see Figure 2 or Figure 9).

Application of ICC Profiles Within the Production/Experiment (Courtesy of Kodak).

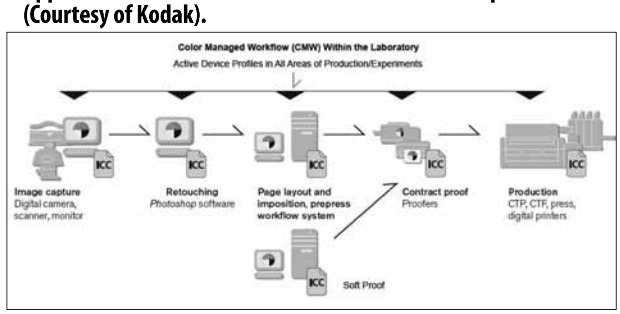

Figure 9

The CIE L* a* b* values of the printed proof were measured with a X-Rite Eye-One PRO spectrophotometer using the ColorShop X application interface. Table 1 presents the variables, materials, conditions, and equipment associated with the scanner, monitor and printer of this experiment.

Table 1: Experimental and Controlled Variables.

Variable	Material/Condition/Equipment
Test Image	UW-Stout Test Target
Scanner	Fuji C-550 Lavonia High-end scanner
Scanner Target	ANSI/ISO IT8.7/2
Profiling Software	Monaco Profiler 4.80 (Gold)
Profile Inspection Software	ColorThink & Monaco GamutWorks
Image Editing Software	Adobe PhotoShop CS-3
Page Layout Software	Adobe InDesign CS-3
Color Management Module (CMM)	Adobe (ACE) CMM
Rendering Intent	Absolute Colorimetric
Computer & Monitor	Apple G4/LCD
Raster Image Processor (RIP)	CGS-ORIS
Printer	EPSON Stylus PRO-4880
Printer Target	ANSI/ISO IT8.7/3 (963 Patches)
Toner	EPSON Inkjet
Paper (sheetfed)	Kodak Matchprint Pro Super White
Type of Illumination/Viewing Condition	D50
Color Measurement Device(s)	X-Rite Eye-One PRO Spectrophotometer with iO Table & Monaco OPTIX Colorimeter
Data Collection/Analysis Software	X-Rite Color Port, ColorShop X & MS-Excel

Test Image for Printing.

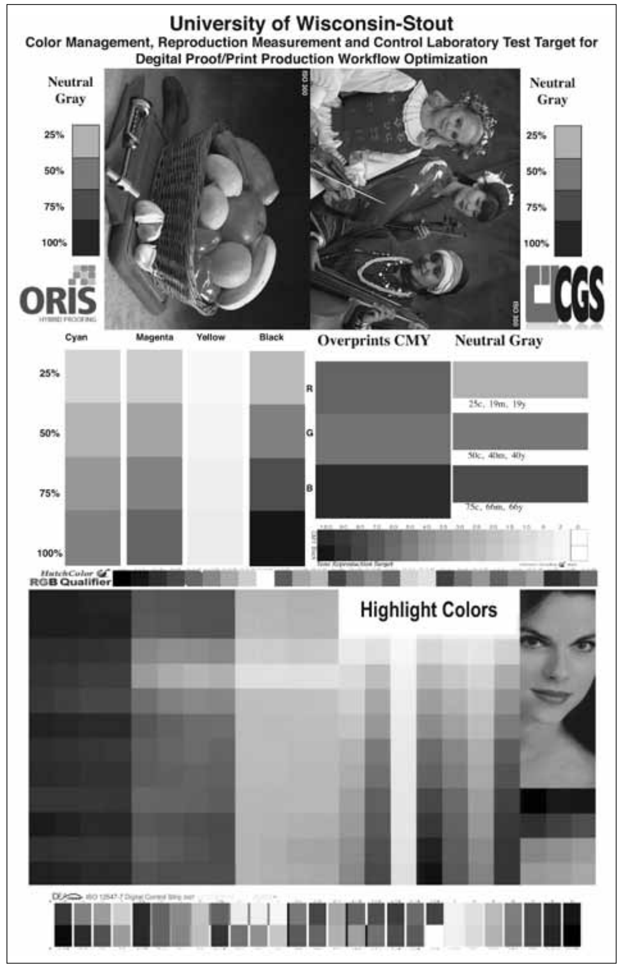

Figure 10

Data Analysis and Research Findings

The printed proof was analyzed by using an X-Rite Eye-One Spectrophotometer and CIE L* a* b* values of CMYKRGB colors were measured at the solid color areas on the printed proof. Colorimetric computations were used to analyze the data. Color difference (Δ_E) was also calculated to see the noticeable color differences that exist between the CIE L* a* b* values of monitor vs. printed proof. Subjective judgment on color difference was not used (or applied) in this study. The subjective judgment of color difference could differ from person to person. For example, we see colors in an image not by isolating one or two colors at a time (Goodhard & Wilhelm, 2003), but by mentally processing contextual relationships between colors where the changes in lightness (value), hue, and chroma (saturation) contribute independently to the visual detection of spatial patterns in the image (Goodhard & Wilhelm, 2003). In comparing the color differences between two colors, a higher Δ_E is an indication that there is more color difference and a lesser Δ_E is an indication of less color difference. Analyzed results are presented in the following section.

Color Difference in the Solid Color Area of Monitor vs. Printer

The CIE L* a* b* values associated with the CMYKRGB colors in the solid color area of monitor vs. proof are compiled in Table 2. Numerical color differences (Δ_E) were found when comparing the color in the solid area of the monitor to the printed proof on all seven colors (CMYKRGB). Also, a noticeable visual color difference was found in the solid color area of the monitor reflectance (L*), color hue, and chroma (a* and b*) values for CMYK RGB color compared to the printed proof.

Table 2: Color Variation in the Solid area of CMYKRGB Image on the Monitor vs. Printer.

	Soft Proof (G4/LCD)			Printed Proof(Epson 4880)			Color Difference Δ_E
	L*	a*	b*	L*	a*	b*	
Color(s)	Color 1			Color 2			
Yellow	79	14	94	77.46	15.02	92.52	2.37
Red	39	56	43	39.38	53.42	42.78	2.62
Magenta	43	61	-36	43.58	59.55	-38.25	2.74
Blue	19	34	-66	20.14	32.77	-67.22	2.07
Cyan	53	-39	-41	53.76	-44.00	-41.02	5.06
Green	44	-51	38	43.23	-52.96	37.34	2.20
Black	9	-1	2	8.12	-2	-5.65	7.35

Overall, both devices have similar color gamut in the solid areas (see Figure 11), except the printed proof consists of higher color value for the cyan.

The 2D color gamut comparison (see Figure 11) reveals that the color of the image displayed on the monitor closely matches the printed proof. The goal was to match the displayed image color to the printed image. The comparison is an indication that, in a CMW, color matching of a target image can be achieved from device to device regardless of device color characterization and original colors. Subjective judgment was not used for the color comparison.

CIE L* a* b* Model (2D) for Solid area of Image Color Comparison of Display Proof and Printed Proof vs. Original Image Colors.

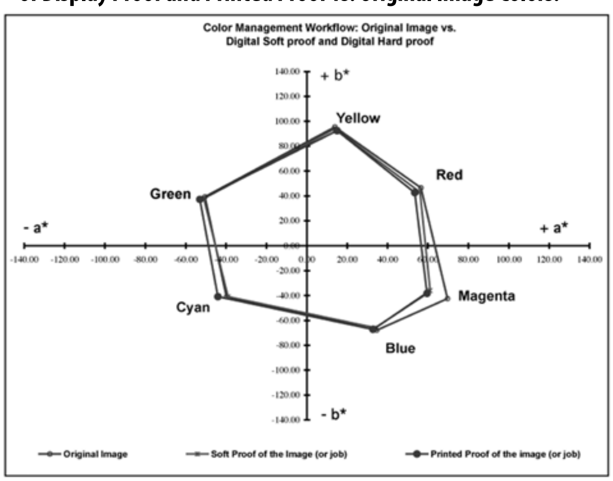

Figure 11

Conclusions

The contents of this research report demonstrated the complete color management workflow implementation (or integration) within a graphic communications laboratory to optimize the digital proof/print production process. The conclusions of this study are based upon an analysis of the data and major findings. The findings of this study represent specific printing or testing conditions. The monitor, scanner, printer, instrument, software, and paper that were used are important factors to consider when evaluating the results. The findings of the study cannot be generalized to other CMW. However, other graphic arts educators, industry professionals, and researchers may find this study meaningful and useful. For example, educators can implement the similar or presented model (or method) to teach color management.

This study found that a Color Management Workflow made it possible for our printers and monitors to produce nearly identical colors. This is due to the integration of color management in our existing workflow. As seen in the device profiles (profile graphs), all the devices present totally different color gamuts. However, the application of CMS offered us more control over colors and tonal values when reproducing color images. It allowed us to accurately and consistently reproduce color with predictable results from device to device.

Application of CMS cannot match output (display or printed) with the original image. It is impossible to accomplish this. Also, it may not be possible to match exactly a color gamut of one device to another device. The goal of CMS is to ensure that colors we see on the monitor are a close match to that of the output of the printer.

As a result of this experiment, we learned that CMS works and it offers us more flexibility and control over our color reproduction images. We also learned that only the optical aspects of color are quantitatively analyzable and measurable because humans perceive color subjectively. It will be hard to document and measure the color values we see or detect. Additionally, the implementation of CMW is costly, time consuming, and is a tedious process. It does, however, benefit those who implement color management workflow in the prepress and printing areas to get consistent color from device to device. Future study is needed to determine the color image differences of color management workflow vs. non-color management workflow. This study was limited to inkjet printer only. Future studies can be conducted by using an offset printing process.

References

Adams, R. M. and Weisberg, J.B. (2000). *The GATF Practical Guide to Color Management.* GATF Press, Sewickley, PA

Fleming, P.D. and Sharma, A. (2002). Color Management with ICC Profiles: Can't live without it So Learn to Live with it. *Gravure Magazine*, p56.

Goodhard, M.M. & Wilhelm, H. (2003). *A New Test Method Based on CIELAB Colorimetry for Evaluating the Permanence of Pictorial Images.* [Online]. Available: http://www.wilhelm-research.com. [2009, August 20].

Hutcheson, D. (2001). *Principles of Color Management.* [Online]. Available: http://www.hutchcolor.com/. [2009, September 10]. Washington, NJ

International Color Consortium (ICC). (2009). *About ICC.* [Online]. Available: http://www.color.org/ [2009, July 29] Reston, VA

Sharma, A. (2004). *Understanding Color Management.* Thomson Delmar Learning. Florence, KY

This is a juried article

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Instant Photo Printing Technology and Usability Test

by Chris Lantz, Ph.D, Western Illinois University

Introduction

Polaroid, or instant film photography, is considered an obsolete technology by many photographers as a result of the instant feedback available with digital photography. Portable printers, such as the Polaroid Pogo, are available for cell phones and Pictbridge compatible digital cameras for those who need instant digital hardcopy in the field (Figure 1). The Polaroid Pogo digital instant camera has been available for almost a year (Figure 2). The Polaroid Pogo prints are 2×3 inch self adhesive backed prints. Pogo printers and cameras that produce larger prints are planned. Polaroid ceased producing instant film in February 2008. In spite of these facts why was a movement started to bring back instant film? This paper details the instant film and Polaroid portable “ZINK” based Pogo digital printer and camera products available today and provides a comparison of the technologies for educational use.

Polaroid film is now available again. Fuji, in Japan, never stopped producing instant film under license from Polaroid. It works in their Intax instant cameras and with some Polaroid film backs for large and medium format cameras. Polaroid film was primarily known as an instant amateur format and today it is a niche product for industrial applications, fine art, and photo education. Some would consider the form factor of the integral film pack print with the white space on the bottom that held the chemistry pod as an iconic cultural object. The Polaroid print borders are mimicked as print borders in Photoshop or Powerpoint slides.

Short Polaroid History

Edwin Land developed a simple and low-cost way to manufacture polarizing material used for glare reduction in sunglasses and cameras (Mcelheny, 1998). The polarizing material also had industrial applications such as

The Polaroid Pogo printer is Pictbridge compatible and can print directly from a digital camera in the field. It takes ten sheets of media at a time in which the first is a smart sheet in the foreground. It can also print via Bluetooth from a cell phone or a computer.

Figure 1

Polaroid Pogo instant digital camera.

Figure 2

Before computer modeling was common, the stress points of prototype products could be predicted with cross polarization or dark field illumination techniques. Dark field illumination is used today for optical microscopy.

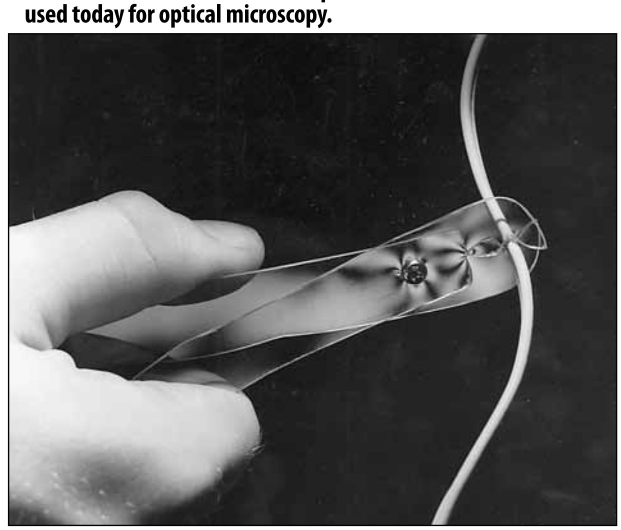

Figure 3

detecting stress patterns with cross polarization in translucent material as in Figure 3. Land later created the peel-apart black and white instant print roll film and Polaroid Land cameras in the late 1940's (Mcelheny, 1998). The roll film was replaced with a ten print pack film. Other subsequent types of instant film included single sheet 4×5 and 8×10 film, a positive/negative sheet film where the negative could be enlarged, color pack film, and then the integral color print film for the SX-70. The integral development process eliminated the need to coat the final print with a fixative or peel and discard a negative paper with wet development jelly. The film also was able to reproduce fine detail (Figure 4). The SX-70 camera had through-the-lens focusing and a compact folding form factor. A later camera released in the late 70's had the first autofocus system in a consumer camera that used sound waves or sonar to detect focusing dis-

Polaroid SX-70 print with enlarged section.

Figure 4

The 1973 Polaroid SX70 camera is on the right. This first generation SX-70 had manual through-the-lens focusing. A late 1990's descendent is on the left and has added flash and sonar based autofocus features.

Figure 5

Image detail from Polaroid Polachrome instant 35mm slide film that used additive red, green, and blue color synthesis for color reproduction in the form of tiny discrete RGB filters on top of a black and white instant film surface. The filters are visible as linear-pixel-like grain in this magnified image.

Figure 6

tances (Figure 5). An early failure for Polaroid was instant movie technology. Polavision movie cameras came out about the same time as costs lowered for professional video products (1977–79). The failure of Polavision was later transformed into a family of successful instant 35mm slide film products that many in prepress remember as being difficult to scan (Figure 6).

Kodak had instant film cameras in the 1980's, some of which had a hand crank mechanism to eject the print. Kodak lost a suit for patient infringement brought by Polaroid and had to refund customers who purchased the cameras.

Polaroid 600 series film was the last film type. Polaroid went bankrupt and reorganized in 2001 and in 2008. Its trademark has been used for a wide range of electronic consumer products since the bankruptcies. Polaroid has also recently taken an interest along with the *"Impossible Project"* company in reviving the Polaroid One-Step instant film camera as well as other Polaroid film products.

Instant Film Cameras

New Polaroid cameras and film can be purchased online (http://www.polapremium.com/). This website was created by the Impossible Project, which is a company in Netherlands that has leased a Polaroid factory including all equipment for ten years and employs 12. Ten employees are former Polaroid personnel, many of whom worked in the factory. Some of the cameras and films they currently sell are old-stock with additional new films planned for mid 2010. The last old stock Polaroid film expiration date is October 9, 2009. The Impossible Project has completed an agreement with Polaroid for use of the brand. Since this film is currently not shipped from the U.S., it is not the most economical choice.

The Fuji instant camera line has been available in Europe since 1997, but has also been available in the U.S. since December 2008. The Fuji Instax cameras are available at

Fuji Intax 200 instant film camera. This is the entry level $50 Intax with zone focusing.

Figure 7

A Polaroid integral print form factor on the top with the more panoramic format Fuji Intax integral print on the bottom.

Figure 8

Walmart, Amazon, and most photo retailers that stock Fuji professional film products. The Intax camera pricing is lower than the current Impossible Project cameras and film. The Fuji products are marketed to some of the original more cost-conscious Polaroid consumers. These have included police, forensic, or insurance applications where portable digital printers are not reliable. Intax 200 film is available in a two pack for $15.95. Each film pack has ten exposures. The Intax 200 camera is $50 (Figure 7). Intax 200 prints are 3.90×2.44 inch in size, which is a slightly wider format than the most common Polaroid 600 series film (Figure 8). The smaller form factor Intax Mini 7S produces a smaller 1.81×2.44 inch sized image area and uses Intax Mini film, which is $14.95 for two ten packs.

The Intax cameras are powered by four AA batteries, unlike Polaroid cameras where the batteries are part of the film pack. The focus on the Intax is zone-focus that is not unlike the Polaroid entry-level cameras such as the One-Step camera. Two settings are provided: ".9 to 3 meters" and "3 meters to infinity." Two more expensive autofocus Intax models are presently only available overseas. Print density can be adjusted by a "light/normal/dark" setting. A built in electronic flash is provided that works well as a fill flash outdoors (Figure 9). A separate optical viewfinder is provided on the camera, unlike the SX-70 that had a through the lens (SLR) viewing system. The two main disadvantages of the camera are limited close-focusing ability and lack of autofocus, which were features available on the more expensive Polaroid cameras.

The color balances of the Intax images seem more neutral than Polaroid 600 film. There also seems to be a greater color consistency from one film pack to another when compared to recent Polaroid 600 film. There is a slight diffusion of the sharp details caused by the development process, and this becomes more evident when scanned at a larger size (Figure 10). Peel-apart instant black and white film does not have this image artifact. Some would describe this diffusing of sharp detail as the unique character of an instant color film image. The yellow color shifts that are common with Polaroid prints were not as evident with the Fuji material. The optical quality of the Intax lens is comparable with the Polaroid One-Step cameras with sharp detail through to the corners of the prints, unlike some inexpensive fixed focus instamatic lenses of the past (Figure 11).

The built in flash on the Fuji Intax was used as a fill light for this print

Figure 9

Image detail of a Fuji Intax print illustrating the image bleeding or diffusing effect .

Figure 10

The limiting factor of the Fuji Intax 200 is not the resolution of the film but the optical quality of the lens and the lack of autofocus, when instant film is used in conjunction with large and medium format cameras with manual focus, the resulting images are sharp.

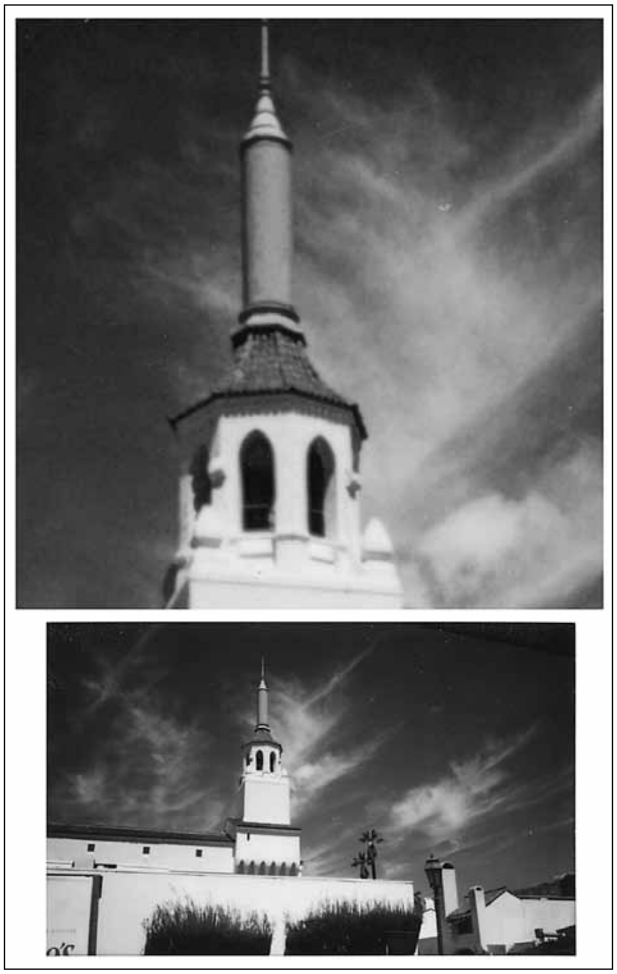

Figure 11

Instant Film For Testing and Preview

Another existing market for instant film is photographers and photo educators who use large and medium format cameras. Professional legacy film-based camera equipment keeps its value over a longer period and is durable and serviceable. Such cameras are also available new with service and technical support. Most of this equipment is compatible with digital backs, although the instant feedback possible with instant print film is less expensive. The used prices on this equipment are also at historic lows. Some photo educators have recently started using older film based equipment again, including Polaroid backs, for these reasons.

With a large and medium format camera, instant film is used to preview and judge the accuracy of the final film exposure (Figure 12). The photographer can compile conversion scales to accurately convert instant film exposures to different 4×5 film stocks, such as transparency or color/B&W negative films. Such conversion charts are especially accurate for those who stock quantities of the same emulsion batch of film. Reciprocity can also be calculated into these conversion scales from the film manufacturer data for long exposures such as at night. For a large format camera, instant film can help confirm bellows compensation calculations. Bellows compensation is necessary when the distance from lens to film is

The exposure of these low key subjects lit by a harsh spotlight without a fill light (for texture) is difficult to meter without a Polaroid test exposure or a film plane meter for film based photography on a large format camera.

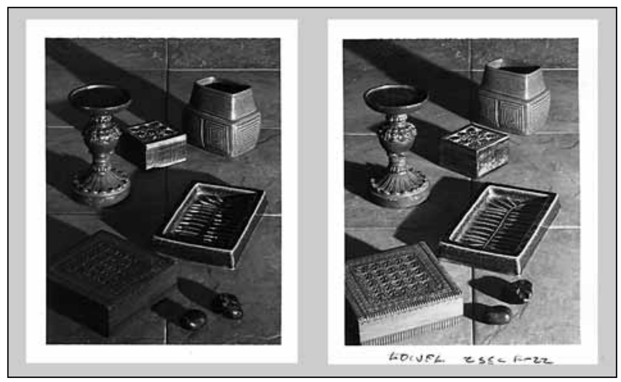

Figure 12

The accuracy of bellows length compensation for close-up work on a large format camera is easy to determine with a Polaroid test exposure. Two stops more exposure was required on the left with three stops of additional light necessary on the right beyond the metered exposure.

Figure 13

increased in order to focus on closer subjects with the large format camera. This is most often calculated with the use of a scale or ruler such as made by Sinar or Calumet. An increase in exposure is necessary to compensate for the increased distance (Figure 13). Film plane meters are available with meter probes that can be moved within the image area behind the ground glass on the large format camera. Focal plane metering equipment is much more expensive than instant film equipment, but automatically accounts for bellows compensation.

A Polaroid or instant film back is also sometimes useful to use in conjunction with a digital back on a large format camera. Instant film prints can be used on location to

Fuji instant prints made with a large format camera were used to determine depth of field (top) and soft focus lens effects on the bottom photo. The bottom photo was taken through a single element magnifying glass lens.

Figure 14

Reflective objects are very sensitive to light and camera angle. Polaroids can be used to confirm the final light and camera position in this class demonstration setup with a large format camera.

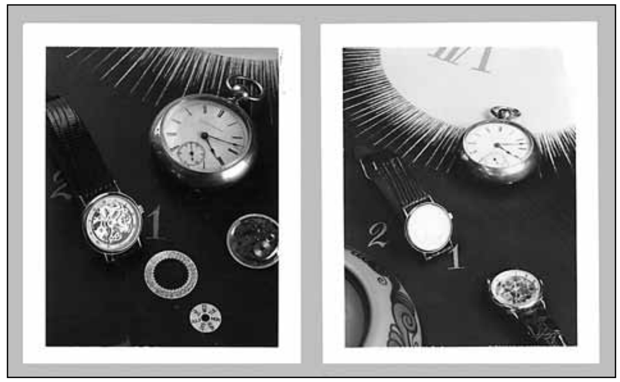

Figure 15

pass out to students or clients to approve or illustrate exposure, depth of field (Figure 14), lighting (Figure 15) and composition (Figure 16). One example is the black glass shot in Figure 17, where the movement of one inch could create a different reflection on the black glass and instant film was used to confirm the final exposure.

Fuji makes film that works in most Polaroid backs for medium format cameras (Figure 18). This is a peel-apart black and white ten print pack film 3.25×4.25 inch in size that is available in 100-speed (FP-100b–$9.75) and 3000 speed (FP-3000B–$9.90). It is also available in 100-speed color film (Fujicolor FP-100C–$8.49). Medium format backs that take this film pack size are common on the used market for $35–100. The size of the prints will be limited to the format of the medium format camera such as a 2¼ inch square image with black borders. This film can also be used in large format cameras, which can take advantage of full print size (Figure 19). The supply of instant film backs to fit on 4×5 inch cameras is more limited and prices can be $150–200 for a used Polaroid 500 pack film back (Figure 20). Fuji makes a new PA-145 pack film back for $208, and is available only at overseas online vendors in the U.S. The other more expensive alternative for the 4×5 camera is to use the 4×5 inch sized Fuji PA-45 back (Figure 21). The PA-45 is $209 and is shipping in the U.S. but the film is more expensive. This is a 4×5 peel-apart ten print pack film that is available in a new 100-speed black and white film (FP-100b 4×5-$28.95) and 100-speed color film (Fujicolor FP-100C45-$29.95).

Fuji instant prints were used on location to predict cropping and perspective compression with different lenses (135mm on top and 210mm on the bottom) for the same subject with a large format camera.

Figure 16

Polaroid ZINK Technology Usability Test

The price of a Pogo printer is $50 and the Pogo camera is $200. The media is inexpensive compared with instant film at $12 for 40 sheets and $20 for 80 sheets. The ZINK media has an expiration date printed on the packaging, not unlike instant film products. ZINK Zero Ink® Printing Technology means zero ink or heat are used to create color in the paper. The Pogo printer/camera needs to cool down after ten prints because the print head heats up. The archival nature of the ZINK material was not clear, because no fade test data was available. Polaroid black and white film based prints are very stable. Peel-apart black-and-white prints from the early 1980's show no signs of fading or discoloration (the author does not have prints from an earlier time period). Color Polaroid prints yellow with time and can fade if not stored in a dark environment.

ZINK based prints can have light discolored spots or lines in small areas, as in Figure 22. If studied under magnification, the fine detail in the ZINK prints have a rasterized pattern and slight stair-step effects to the straight lines that are not present in the digital file under the same magnification. Similar artifacts are not present with instant film. Film grain is visible under magnification for the ISO 400 and 3000-speed instant films (Figure 23).

Diffusion lighting flats illustrated in the Polaroid on the left were used to create the gradation on a black glass background. A Fuji instant print (right) was used to determine the correct lighting pattern to use on the diffusion flat for reflection onto the black glass.

Figure 17

Pack film backs compatible with Fuji instant film mounted on 2¼ inch square (left) and 6×7 cm (right) medium format cameras.

Figure 18

Both the Pogo camera print and the black and white ISO 3000 speed Fuji instant film seem to resolve the same amount of detail. ZINK did quite well in resolving detail, considering it is a smaller sized print, as illustrated in Figure 24. It now has a low cost, but modern lens design. The instant films also did well, considering that the lens used was a 90mm wide angle Optar from the 1950's, for Figures 23 and 24. Grain is barely perceptible with ISO 100 instant Fuji film, and it resolved more detail or at least produced a sharper image with fewer artifacts than the Pogo camera print.

The tests made for Figure 23 are not definitive because variables, such as the smaller ZINK print size and the fact that the ZINK prints were color and the instant film prints were black-and-white were not controlled. This is a typical example of a usability test that photographers often perform when comparing different products. The test subject was unusual because it was not a resolution chart, but it did provide similar fine detail. The results of the test were useful in a local adoption decision of ZINK technology. It is valid in respect to testing current Pogo and ZINK technology as a possible replacement to current instant film products for a specific instructional application (photo education field demonstrations).

If the Pogo camera and printer were capable of producing larger prints, this would make the technology more comparable, at least in size, with instant film cameras available now. The 2×3 inch prints are just too small to properly evaluate images (without a good 8x magnifier) and pro-

Fuji PA-145 pack film back (front) with a Polaroid 500 back mounted on the large format camera. Both backs work with the Fuji 3¼ × 4¼-inch instant films.

Figure 20

400 speed 4×5 Fuji instant film image on the bottom of the same interior shot on a large format camera. The image on the bottom was 3000 speed film that has lower contrast.

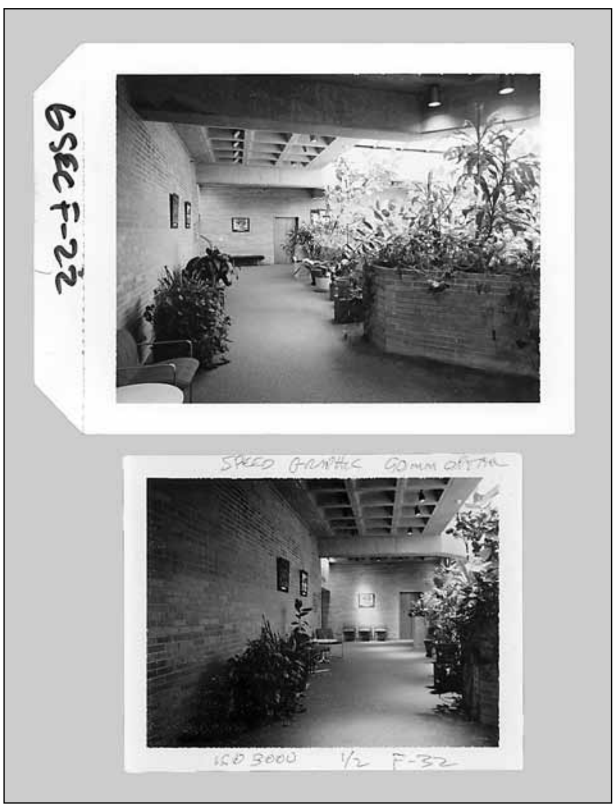

Figure 19

The 4×5 inch Fuji PA-45 pack film back (front) is thicker than the old Polaroid 545I 4×5 single sheet back (rear). This makes it more difficult to mount under the ground glass of some 4×5 cameras.

Figure 21

Image artifact, common with Pogo prints, which results in image loss especially along the edge of the prints. Instant film also has its share of image artifacts if the rollers are not cleaned.

Figure 22

vide less information than most high quality camera displays. It is more useful to pass around a digital camera so students can look at the camera display (shielded by black cardstock on a bright sunny day), rather than use the Pogo's 2×3 inch prints. The Pandigital Zero Ink PANPRINT01 is a 4×6 inch printer with the new larger sized ZINK print engine, which will also be used in larger Polaroid instant cameras but is currently not shipping (February 2010).

Pogo Printer

Printer drivers are not available for the Polaroid Pogo printer and printing directly to the device in an application is not possible. A laptop is necessary to download files from a large or medium format digital back via USB or Firewire cable, because neither Pictbridge nor

Enlarged image detail from a Commodore Amiga bumper sticker in a faculty office. 100-speed Fuji FP-100b black and white instant film, 400 speed Polaroid Type 52 film, 3000 speed Fuji FP-3000B instant film and print from a Pogo camera is on the bottom.

Figure 23

Pogo camera print (top) and Fuji ISO 100 instant film print (bottom) of the same scene that enlarged image sections were taken for Figure 23. The prints were scanned at 1200 DPI. The arrows indicate the areas that were enlarged.

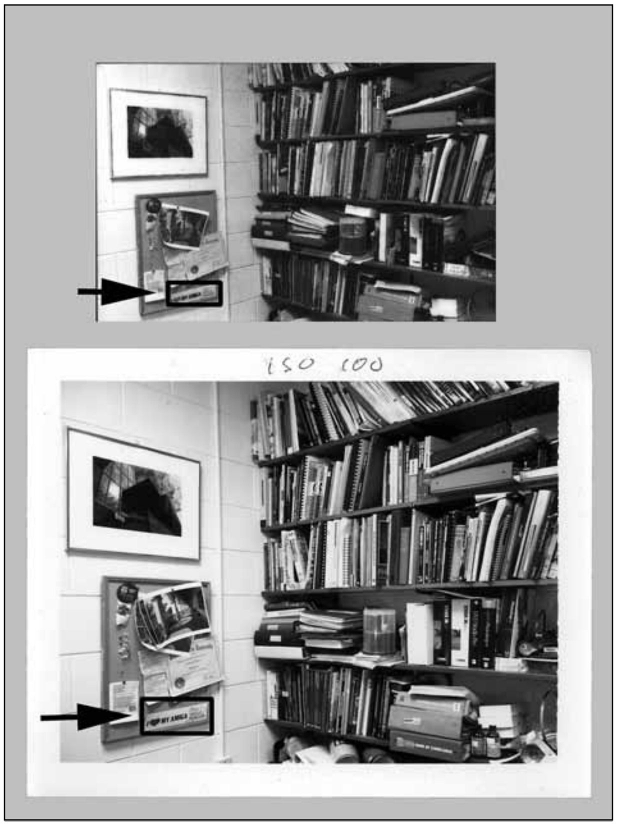

Figure 24

Bluetooth support is available on these devices. The computer must have Bluetooth built-in or a USB Bluetooth dongle can be used to connect to the printer. The advantage of the Pogo prints is that quick optimizations can be made to the image prior to printing on a laptop. A greater degree of quality control and attention to detail is needed by the instructor when using instant film because it is a direct print process with all optimization done at the time of exposure.

If the printer is being used for the first time, it is paired to the computer in the Bluetooth preferences and a pass code is entered. The files can then be "sent" to the printer via Bluetooth for printing on a Mac or dragged and dropped onto the connected Pogo printer icon in Windows: "My Bluetooth Places." It is a simple process to print on the Polaroid Pogo printer via Pictbridge compatible cameras or Bluetooth connection on a cell phone (no iPhone support). When printing from a computer, all files must be converted to JPEG before printing. The print speed is almost a tie with Polaroid film development, but Bluetooth file transfer, and possible file conversion to JPEG (with a digital back), also takes time. The Pogo printer is a useful product for its intended market, which is mainly prints from cell phones and Picbridge prints from consumer digital cameras. It is a good value at $50.

The Pogo Camera

The Pogo camera is able to print directly from SD cards and it has a three-inch display making it more convenient as a field printer (Figure 25). It has the same 2×3 inch ZINK print engine as the Pogo printer with a fixed focal length (no optical zoom) zone focus lens and a five-megapixel sensor added to the portable package. This camera has the same basic limitations as the Fuji Intax instant film camera with regards to the optical quality of the lens and lack of autofocus. The standard focus mode is five feet to infinity and the macro mode is two to five feet. The built in flash has some additional modes, such as pre-flash red eye reduction. It does have an EV control and bracketing function for density correction, but no manual mode with direct access to f-stop or shutter speed is provided. There are scene modes such as "flow water" which gives the photographer access to a slower shutter speed or "sports" where a faster shutter speed is used for example. Its ISO sensitivities range from 100–400. The light gathering capability of the 2mm wide front optical element of the Pogo camera lens is not significant (Figure 26). Other more useful features include manual white balance and metering modes, such as spot or center. The print menu has a date and frame number imprint function and a frame mode where the Polaroid film print borders can be selected, among others. It does also have web camera and video functions.

Three inch display on the back of the Pogo camera .

Figure 25

Front element of the Pogo camera with a portion of a dime included for scale.

Figure 26

The camera ships with a CD that has web camera drivers and Arcsoft trialware. No printer drivers are included on the disk for direct printing via USB, and no Bluetooth is provided on the Pogo camera. The USB cable is used to print to another printer via Pictbridge, to transfer photos/movies to a PC, or to use the web camera function. Photos need to be copied onto SD cards in JPEG format to print on the camera. Some SD cards formatted on a Nikon camera could not be read on the Pogo camera, and this limits its usefulness in the field. The Pogo camera is at a low price point considering it is a field printer with an SD card slot and a monitor. The camera could be considered an extra value-added capability that most serious photographers would not use beyond the instant print function. Since it is the first portable digital camera with a built in printer, it will nevertheless have a place in photo technology history.

Battery Life

Larger format inkjet or bubble jet printers with battery power have also been available for several years but have limited battery life and can be expensive, heavy, and larger.

Portable digital printing technology is maturing with greater print size, resolution, and connectivity capabilities, but presently it has some power limitations. Nine prints could be printed on the Pogo camera before a new fully charged battery was empty. About 14 prints can be made on the Pogo printer before a new fully charged battery is empty. Perhaps adapting a large supplemental laptop battery is possible? Today, a film camera from the 1950's, used in conjunction with an instant film back, can produce comparable or better high-resolution instant prints in the field without using any power source. The four-AA batteries in the Fuji Intax never went dead, even after six packs of film. Battery life is a major limitation for field work, considering that a spare battery for the Pogo camera and printer was not available (February 2010). The battery for the Pogo printer is not compatible with the Pogo camera.

Conclusion

For many photo educators, darkrooms are no longer available. But students can still see the image develop with an instant print. Polaroid or Fuji instant film is an inexpensive way to introduce film camera history and concepts to the digital photographer. Polaroid is a brand that transcended its obsolescence and its generation of original consumers. Edwin Land conceived of his instant camera film for a mass consumer market and it still lives on in today's digital world in small, but diverse, niche markets. The instant camera is bound to reach a mass market again with future instant digital print cameras.

References

Earls, A. and Rohani N., (2005). *Images of America: Polaroid.* Charleston: Arcadia.

Mcelheny, V. (1998). *Insisting on the impossible: The life of Edwin Land inventor of instant photography.* Cambridge: Perseus.

This is a juried article

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Resourceful Thinking About Printing

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Abstract

Resourceful thinking about printing is much more than a focus on hardware or software acquisition in an effort to amass profit. It is about finding the best tool to get the job done and lowering running costs; getting more for less while eliminating or reducing the negative impact on the environment; and assessing energy, paper, carbon impact, and associated monetary costs. As companies realize that wealth is created through technology and by adding value to natural resources, efforts need to be made to ensure that sustainable practices are put in place to protect the environment. Some of the strategies that can be used to achieve this goal include contributing to environmental and economic sustainability; socially conscious and environmentally friendly products and packaging; establishing safety and efficacy in product design; the use of renewable and recyclable resources; biodegradability; promoting sustainable harvesting practices; and accountability to present and future generations. These strategies are addressed in detail in this paper with examples of how they are being used successfully in the industry.

Need

Technological progress is frequently sparked by creating and advancing technology, economic growth, job creation, and resourceful thinking. Resourceful thinkers are a special breed of people who have the ability to sell or market ideas to others. They possess a particular set of qualities, such as vision, courage, initiative, commitment, persistence, drive, and ambition.

As a result of high energy and chemical use and associated wastes, printing is one of the most polluting industries. Therefore, resourceful thinking about printing is much more than a focus on hardware or software acquisition in an effort to amass profit. It is about finding the best tool to get the job done; lowering running costs; getting more for less while eliminating or reducing negative impact on the environment; and assessing energy, paper, carbon impact, and associated monetary costs. Every well-run business needs strategic goals—these goals need to include sustainability as related to green, renewable, and recyclable as well as profitability. Resourceful thinking about printing needs to build environmentally responsible processes that are lean, green, and sustainable while at the same time profitable to stakeholders.

Overview

Many printing companies have realized that wealth is created through technology and by adding value to natural resources. These printing companies are pushing for technology transfer and technology development and must set standards for sustainable and research responsibility as they relate to their companies. Such standards should include, but not be limited to, safety; effectiveness; sufficient research conducted; honesty about where packaging was sourced; honesty about claims related to packaging; affordability; build value to equity for company; respect for the standards of the Food and Drug Administration; respect for the standards of the Federal Trade Commission; and respect for the standards of organizations.

A number of strategies can be used to promote resourceful thinking about printing. These include a focus on the following major points: contributing to environmental and economic sustainability, social consciousness, environmentally friendly products and packaging, establishing safety and efficacy in product design, using renewable and recyclable resources, biodegradability, promoting sustainable harvesting practices, and accountability to present and future generations.

Contribution to Environmental and Economic Sustainability

Many printing processes use chemicals, some of which are potentially harmful to the environment. Printing companies represent one of the more polluting industries (Blansch, 1995). Printing processes are oftentimes accompanied by pollution which arises as an inevitable result of production processes caused by high energy processing and the use of paper, ink, and chemicals (Masurel, 2007). Resourceful thinking about printing is about directing attention to concern about the environment and the health of workers even as printing companies seek to make profits. As a result, *"adopting environmentally friendly business practices has become an important focus for the printing industry"* (Assadi, 2009).

The Oji Paper Group, for instance, obtains 60% of its pulp from recovered paper and the rest from its tree plantations that are managed in strict conformance to Japan's strict environmental standards. As the second largest paper company in Japan, the Oji Paper Group has taken initiatives to help prevent global warming by making concerted efforts to reduce energy consumption and to switch from fossil energy to energy generated from waste by installing new energy boilers. Although the Group sets the targets of reducing both fossil energy consumption per unit of production and fossil fuel-based CO_2 emissions per unit of production by 20% from the fiscal 1990 levels by fiscal 2010, it actually achieved both targets in fiscal 2006.

Based on two principles of *forest recycling* and *paper recycling,* the Oji Paper Group has, over many years, developed a sustainable recycling-oriented business model in its effort to protect and preserve the nature of the world. In terms of forest recycling, the overseas forest plantation was expanded from 200,000 to 300,000 hectares with trees already planted in over 170,000 hectares. In terms of paper recycling, the Group's recovered paper utilization rate has already reached 60% with efforts to push this level higher continuing.

Oji operates 16 mills in Japan and has subsidiaries and affiliates in overseas markets in Asia, Europe, and the Americas. The group annually manufactures over seven million tons of printing and writing papers, corrugated board, and boxboard as well as packaging and wrapping papers, paper-based containers, thermal papers, plastics, and disposable diapers. It is also involved in the production of chemicals for papermaking and packaging.

Socially Conscious, Environmentally Friendly Products and Packaging

There has been increasing pressure from the public and investors about environmental and energy issues. Evidence of increasing mainstream public support for issues relating to climate change and our carbon footprint can be seen in the success of Al Gore's film, *An Inconvenient Truth.* Carbon footprint is as a result of the imbalance between the collective output of carbon dioxide and other greenhouse gases by human activities and the earth's ability to process them (Parsons, 2006).

The print lifecycle involves fiber, minerals, chemicals, and energy used to make the paper, ink, and other essential materials as well as the energy and materials used in print manufacturing and distribution up to the final disposition as wastes. However, transportation of raw materials to paper mills, mills to the printer, printer to consumer, and then final disposition, as well as recycling of products and the post-consumer recycled paper content, are also important and represent aspects of sustainable product life cycle management that need to be considered. According to Parsons (2006), *"Because printing is ubiquitous and since it is likely to remain that way, the life cycle aspects and impacts of printing and publishing are likely to come under increased scrutiny"* (p. 5). According to the American Center for Life Cycle Assessment (2009), a life cycle consists of consecutive and interlinked stages of a product system, from raw material acquisition or generation of natural resources to the final disposal.

Decisions taken at multiple stages of the printing process should therefore take into account the need for socially conscious, environmentally friendly products, as well as packaging and disposal systems that support the growing movement for environmental sustainability. A number of printers are showing commitment to co-generation and purchase of green energy as a demonstration of their growing concern about climate change and energy security. For instance, Cenveo Anderson Lithograph, a Los Angeles based printer, generates all of its own electricity. In addition, the company has a system that captures and destroys all of the volatile organic compounds (VOC) emissions generated by their printing operations, reduces the nitrogen oxide and carbon dioxide emissions associated with combustion of natural gas fuel by as much as 85%, and produces lower emissions than the local electric utility (Parsons, 2006).

According to Assadi (2009), Greenerprinter, a commercial printer, offers sustainable, eco-friendly printing and mailing services to local and national companies. The company uses technology to eliminate inefficiencies, streamline communications with customers, and make operations more eco-friendly. One approach, which has resulted in an immediate impact, is the adoption of an all-digital workflow from the design and pre-production stage and extending up to proofing and delivery of files to the press. They use a Job Definition Format (JDF) to route documents through the workflow steps. This enables them to specify the ink zone settings, press setup instructions, and cutting and folding directions for JDF-enabled devices. A major advantage is that "The JDF-enabled PDF files speed throughput, reduce errors, conserve paper and energy, and lower production costs" (p.19). In addition to computerizing prepress operations to eliminate the need for photochemicals, the company established a recycling program for solvents, uses alcohol-free printing, prints exclusively on recycled paper , and uses low VOC inks and energy-efficient equipment.

Kilmer, Wagner, and Wise Paper Company, a paper and shipping products distribution company, is committed to environmental packaging. On its web site, it states that all its products (corrugated cartons, bubble pack, foam, poly bags, can liners, towels, toilet tissue, kraft wrap and starch based flowables) are made of partial to 100% recycled materials. For instance, the company claims that its flowable (PELASPAN-PAC NATURAL) is completely natural, 100% biodegradable, no CFCs, non-static, non air-polluting, renewable, recyclable and reusable, and with no dependence on oil (Kilmer, Wagner, and Wise).

Establish Safety and Efficacy in Product Design

Some of the measures that can be taken to enhance safety and efficacy in the design of printing products include the use water-based aqueous coatings to protect printed pieces. This provides a high-gloss surface that deters dirt and fingerprints and is more environment friendly than UV coatings. Also, inks that are vegetable-based, primarily soy, which are both gentle on the environment while producing bright, high-quality images, should be used. Paper should be milled Elemental Chlorine Free. This is because trees are a renewable resource, but dioxin (used to bleach paper white) is permanent.

Other measures include:

1. Alternative paper choices—the use of treeless papers made from alternative sources such as bamboos, sugar cane, stone, and plastic. Also, the use of 100% post-consumer waste-recycled paper.
2. Online printing using Repro Graphics—by placing orders, sending files, and receiving electronic proofs by computer.
3. Recycling—of all paper trimmings, ink, and toner cartridges.
4. On-demand printing—using digital color presses.
5. Vegetable-based inks—provide for chemical-free water-based printing.

Additionally, there are sustainable efforts that have been introduced to reduce wastes and to enhance the efficacy of the print production process. For example, UC-Davis recommends:

1. The use of eco-board poster boards—these are used to mount posters on materials made from recycled cardboard.
2. CD and DVD production—offer discs to reduce paper.
3. Poster stand rental—simply rent and reuse rather than purchasing them.
4. Environmentally friendly direct-to-plate imaging.
5. Two-sided printing—to be used as necessary; reduces paper use.

Renewable and Recyclable Resources

Recycled paper is readily used in the newsprint and packaging sectors. The use of recovered fiber in newsprint reached 87.5% in Europe in 2007, with many of the countries, including, the United Kingdom, achieving 100% (Cox, 2009). Recycling paper is very widely practiced in many businesses. In addition, companies are taking the initiative to move into the recycling of all kinds of waste to cut costs and also for the sake of environmental protection. For instance, ecoproducts.com stated on their web site that they compost or recycle all wastes at their facility, including all food waste, PLA packaging scraps, food service ware, the waxed backing of UPS labels, and so on. Examples of items they recycle are pallet wrap, scrap wood, scrap metal, printer cartridges, paper, commingled containers, and cardboard.

Biodegradability

Biodegradable products are capable of decomposing into nontoxic soil, water, carbon dioxide, and methane. The Biodegradable Products Institute (BPI), a non-profit organization of individuals and groups from government, academic, and business sectors, have set standards for biodegradability. The institute's compostable label program has been used to educate legislators, manufacturers and consumers about the importance of scientific-based standards for biodegradable materials (Biodegradable Products Institute).

The use of biodegradable padding materials for packaging, instead of petroleum-based foam "peanuts" that are harmful to the environment, is an example of a way to adopt biodegradability in fostering environmental sustainability. There are several companies that are promoting eco-friendly, biodegradable products. For instance, ecoproducts.com listed a number of ecoproducts on their web site, including compostable paper food containers (soup cups, food containers made from corn, take-out boxes), and biodegradable bagasse soup containers.

Promote Sustainable Harvesting Practices

Efforts to promote sustainable harvesting practices is crucial for the printing industry and this could be in terms of sustainable energy harvesting as well as good harvesting practices for all other products in the entire print lifecycle. Printing requires a high amount of energy, water, paper, inks, and chemical usage. Resourceful thinking about printing should consider and adopt harvesting best practices to drive down production costs as well as to promote environmental sustainability. For instance, in the area of energy harvesting, an energy harvesting power management system is capable of capturing, converting, storing, and delivering energy to power systems. An energy harvesting system will typically be composed of a collector or transducer device. The energy collected is then converted to a form that can be used depending on whether it is for lighting (photovoltaic or solar energy), heating (thermoelectric), or movement (kinetic). The final stage of the system is to condition it for storing the energy and managing it in terms of distribution to where it is needed based on system operations or other needs in the plant.

Other best practices for sustainable harvesting could include placing trays and collection boxes at strategic points in the plants to collect recyclable materials and products, such as used ink cartridges, paper, chemicals and water. These materials are then transported to the recycling system and new usable products are produced from them. In addition to saving costs, the impact of these on the environment is beneficial to everyone. The important point here is to ensure that this is communicated to everyone and periodic reports demonstrating the effectiveness of this approach as well as the gains that have been realized from it should be made known to all. This will boost morale and make everyone buy in to the adoption of these practices in the plant.

Present and Future Generations of Packaging Products

Considerations for the packaging of products of present and future generations require thinking about sustainability of the packaging. In terms of product packaging, the Sustainable Packaging Coalition (SPC) has defined sustainable packaging as a packaging that meets the following conditions:

1. Is beneficial, safe, and healthy for individuals and communities throughout its life cycle;
2. Meets market criteria for performance and cost;
3. Is sourced, manufactured, transported, and recycled using renewable energy;
4. Maximizes the use of renewable or recycled source materials;
5. Is manufactured using clean production technologies and best practices;
6. Is made from materials healthy in all probable end of life scenarios;
7. Is physically designed to optimize materials and energy; and
8. Is effectively recovered and utilized in biological and/or industrial cradle to cradle cycles.

This definition is in tandem with the vision and mission of the coalition. For instance, the vision of SPC is that all packaging be responsible sourced, designed to be effective and safe throughout its lifecycle, meets market criteria for performance and cost, made entirely using renewable energy, and when used is recycled efficiently to provide valuable resources for subsequent generations.

The Paperboard Packaging Council (PPC) provides the following sustainable advantages of using paperboard products in packaging. These are in terms of:

Materials Sourcing: A sustainable material is made using specially-raised crop trees, waste products like sawdust and wood chips, and recycled paper/paperboard fibers. Sustainable wood fiber from farm-raised trees is the primary raw material in paperboard packaging. The forest products industry plants 1.7 million trees a day—planting five for every one that is harvested. Further, paperboard is recyclable, and collected fiber returns to the mill for paperboard production.

Physical Design: Improved designs and manufacturing processes have reduced raw material needed without sacrificing performance. There is also a reduced need for labels or additional information displays—most information and brand information needed can be printed on paperboard. The weight of paperboard has fallen while board strength has increased allowing packages to be designed with lighter, thinner paperboard.

Clean Production: Continuous improvement is being made in production processes and new materials. Modern paperboard production has limited chemical usage and lowered air emissions in paperboard production.

Effective Recovery: Paperboard packaging is a valuable resource considering that the fibers in paperboard packaging can be recycled, and usually are, multiple times. Paperboard can also be reused prior to recycling to store other materials after its contents have been used

Summary

Resourceful thinking is about meeting the challenges of creating an environment that fosters scientific discoveries and technological development. It involves the ability to know the demands of the environment, to respond to these demands with technological solutions, to create solutions that links the research and matches the research with the actual demands of the environment, and to structure an environment that moves resourceful thinking through the global economic.

References

American Center for Life Cycle Assessment (n.d.). *Life cycle assessment definitions*. Retrieved on October 24, 2009 from http://www.lcacenter.org/LCA/LCA-definitions.html

Assadi, M. (2009). Giving print a green look. *Graphic Arts Monthly*, 81 (6). 18–19

Biodegradable Products Institute. (n.d.) *Welcome to the new BPI World*, Retrieved March 4, 2010 from http://www.bpiworld.org/

Blansch, K. L. (1995). Offset printing companies and the environment. *Business Strategy and the Environment,* 4. 220-228

Kilmer, Wagner, and Wise Paper Company, (n.d.) *Pelaspan-Pac Natural,* Retrieved on March 4, 2010 from http://www.kwwpaper.com/prod_environ.html

Masurel, E. (2007). Why SMEs invest in environmental measures: Sustainability evidence from small and medium-sized printing firms. *Business Strategy and the Environment,* 16 (3). 190–201

Oji Paper Group (n.d.). Retrieved on October 17, 2009 from http://www.ojipaper.co.jp/english/group/message/index.html

Paperboard Packaging Council (n.d.). *The sustainable advantage of paperboard packaging.* Retrieved from http://www.ppcnet.org/SUSTAINABILITY/DontGetGreenwashed.aspx on November 1, 2009

Parson, J. (2006). It's not easy to be green. *Seybold Report: Analyzing Publishing Technologies,* 6 (6). 4–8

Sustainable Packaging Coalition (n.d.). *What is sustainable packaging?* Retrieved from http://www.sustainablepackaging.org/about_sustainable_packaging.asp on November 1, 2009

U.C. Davis (n.d.). *Sustainable practices*. Retrieved on March 4, 2010 from http://reprographics.ucdavis.edu/about-us/sustainability

www.bigskyprint.com/print-paper-environment.pdf

www.printit.org.uk/rdas/pages/.../printing_and_the_environment.doc

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Members of the International Graphic Arts Education Association, or students of IGAEA members, may publish in the *Visual Communications Journal*.

Audience

Write articles for educators, students, graduates, industry representatives, and others interested in graphic arts, graphic communications, graphic design, commercial art, communications technology, visual communications, printing, photography, journalism, desktop publishing, drafting, telecommunications, or multi-media. Present implications for the audience in the article.

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