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Eastern Kentucky University
Richmond, KY 40475-3102
School (859) 622-1190
Fax (859) 622-2357
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Table of Contents

* ... Chris Lantz served as a jurror for the *Journal*, but did not review his own paper.
**... Jerry Waite served as the editor of this *Journal*. However, his article was submitted blindly to the review committee.

Editor's Note

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

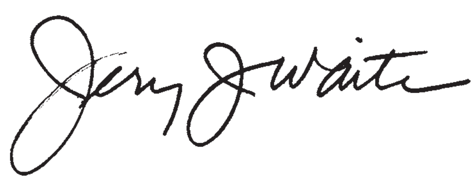
This issue of the *Visual Communications Journal* has something for everyone involved in graphic arts and graphic arts education. Printing industry executives and faculty who specialize in printing management will enjoy an article by Harvey Levenson from California Polytechnic State University. Harvey demonstrates the use of a cube planning model that he based upon a two-dimensional planning matrix employed by Graphic Arts Technical Foundation (GATF) in the 1970s. Using this model, printing industry managers can make decisions about growth technologies and new technologies based upon industry parameters and environmental influences. Managers and print management instructors will also enjoy Devang Mehta's study that compares waterless lithography with conventional lithography on three variables: productivity, eco-friendliness, and ease of operation.

Middle- and high-school graphic arts teachers will certainly enjoy reading Carl Blue's article in which he demonstrates that student access to communications technologies outside the classroom has a significant impact on student learning. Blue found, in particular, that a super majority (75%) of the participants in his study (middle- and high-school communication technology students) have access to the Internet where they live. This finding is higher than the national average. In addition, nearly 85% of the respondents stated they either had access to or use of a personal computer. This finding conflicts with many naysayers who report that American youth lack access to digital tools.

Faculty who teach photography will appreciate Chris Lantz' article on High Dynamic Range (HDR) photography. Lantz provides an overview of HDR and then demonstrates the use of several software tools that can be used to prepare HDR images. Finally, I hope all print teachers will find the second installment of my paper on teaching printing industry guidelines to be useful.

As is often the case in our small-but-productive profession, articles that appear in this edition of the *Visual Communications Journal* were written by a member of the Journal's Editorial Review Board (Chris Lantz) or by the Journal's editor (me). These two articles were submitted to the same peer-review scrutiny as the other papers and were accepted using a double-blind review process. Documentation regarding the voting on these two articles is available by contacting me at **jwaite@uh.edu.**

Finally, thanks to the *Journal's* Editorial Review Board. Due to other commitments, Dr. Lenore Collins "retired" from the review board. Chris Lantz, from Western Illinois University, graciously took her place. Thank you for your service, Chris! In addition, I truly appreciate the time and effort invested by Cynthia Gillispie-Johnson, James Tenorio, Zeke Prust, Bob Chung, Malcolm Keif, and Mark Snyder.



A Comparison of Waterless Litho with Conventional Litho on Productivity, Eco-Friendliness, and Technical Skills Needed

by Dr. Devang P. Mehta, North Carolina A&T State University

Introduction

An empirical research study was conducted to examine the differences between waterless litho and conventional litho on productivity, eco-friendliness, and technical skills required to operate presses. The research study was based on Lamparter (1994) and other studies. A cross-sectional research was conducted. Questionnaires were sent to participants to collect data. A seven-point Likert scale was used to obtain data on productivity, eco-friendliness, and technical skills needed. Descriptive data analysis was performed to answer research questions. It was found that waterless litho is more productive and eco-friendly than conventional litho. Since the major variable, ink-water balance, is eliminated in waterless lithography, lithographers believed it requires fewer skills to operate waterless litho presses. Hence it is easier to operate waterless litho presses in comparison with conventional litho presses.

Purpose

The purpose of this research was to compare waterless litho and conventional litho on three characteristics: productivity, eco-friendliness, and technical skills needed. Productivity included the press makeready as well as running time. The eco-friendly characteristic took into consideration of the types and amounts of materials used and disposed that could possibly harm the environment. The technical skills needed characteristic was related to the degree of ease of press operation.

Problem

Waterless lithography (litho) or dry offset printing (driography) has been in existence commercially since 1977 when Toray Industries, Inc., a Japanese company, introduced the first waterless litho plate to the market. Lamparter (1994) found waterless litho was more efficient than conventional litho because it saved time on makeready. He revealed that waterless litho was more eco-friendly than conventional litho because it did not require the fountain solution and had less paper spoilage. He also found a controversial issue…some printers believed that waterless litho requires fewer skills to operate presses because press operators do not have to worry about ink-water balance. On the other hand, some printers believed that there are other skills required to operate waterless litho presses; for example, maintaining ink temperature. Since Lamparter's study, both conventional and waterless lithography experienced changes such as the use of stochastic screens and direct imaging as well as improvements in waterless litho plates and inks. The purpose of this study was to examine the current differences between waterless litho and conventional litho on three criteria: productivity, eco-friendliness, and technical skills needed.

Research Questions

Based on the review of literature, three research questions were developed.

1. Is waterless litho more productive than conventional litho?

2. Is waterless litho more eco-friendly than conventional litho?

3. Is it easier to operate a waterless litho press than a conventional litho press?

Review of the Literature

This research study was based on relevant information gathered through both primary and secondary sources. The existing literature related to productivity, eco-friendliness, and technical skills needed for both processes, waterless litho and conventional litho, are discussed as follows.

The concept of waterless lithography or driography was first developed by the 3M Company in late 1960s (Cross, 1993, April). The concept was to modify lithography so that there would be no need to use a dampening solution. After several years of research and development, and many millions of dollars invested to solve the technical problems associated with ink consistency and plate durability, 3M sold the concept to Toray Industries, Inc., a Japanese chemical company (What it is, 1997a).

Waterless lithography was different from conventional lithography in that the dampening system was eliminated.

Because of this change, waterless lithography required a special type of plate, specially formulated high-viscosity ink, and a press outfitted with a temperature control system.

The Toray Positive-Acting (TAP) waterless litho plate was first introduced at DRUPA, a graphic arts exposition held in Germany, in 1977. A Toray Negative-Acting (TAN) waterless litho plate was introduced at the Print graphic arts show in the United States in 1980 (What it is, 1997a). The waterless litho plate consists of five layers: (1) an unanodized aluminum base, (2) a primer to bind the photopolymer layer to the base, (3) a light sensitive photopolymer layer, (4) an ink repellent silicone layer, and (5) a protective cover film at the top.

It was stated in "What it is" (1997b) that waterless litho inks have higher viscosities than traditional litho inks. The temperature of the waterless litho ink increases rapidly because of removal of the dampening system. As temperature increases, the ink loses viscosity. To maintain the viscosity of ink, a temperature control system is required.

Since the dampening system was eliminated in waterless litho, all other problems associated with it were eliminated, too. KBA argued that by using waterless printing problems of "fan in" and "fan out" are eliminated (Hayes, 2001a). Macintosh, Sun Chemicals' cold-set chemist, mentioned that waterless litho reduces the problems of tinting and ink misting (Hayes, 2001b). If there are fewer press problems, one would expect greater productivity. Lamparter, in his 1994 study, discovered this assumption to be true when he found that waterless litho was more productive and eco-friendly than conventional litho.

By eliminating the dampening solution, the waterless litho process was a more simplified operation. There were no more concerns regarding pH levels, emulsification of water into the ink, and ink-water balance (Cross, 1993, December). In waterless litho, ink-water balance was replaced with the need for ink-temperature balance. It was very important to maintain temperature at each printing unit because different inks had different temperature ratings (Cross, 1993, October). Thus, there were contradicting arguments regarding the ease of use of waterless litho.

Methodology

A survey questionnaire was prepared for collecting data. Gay (1996) stated that descriptive data are usually gathered through a questionnaire survey, an interview, or an observation. Thus, the survey used for this study collected descriptive data and contained questions regarding demographic information of participants as well as perceptions related to waterless litho as compared to conventional litho on productivity, eco-friendliness, and technical skills needed. The questionnaire was pre-tested for its validity and reliability. A pilot test was conducted to check the validity of the questionnaire, eliminate any ambiguity, and make appropriate changes according to respondents' suggestions. A targeted sampling technique was applied to select the final subjects. Printing companies of the United States who had experience with both waterless litho and traditional litho were selected. Questionnaires were mailed to middle-level to top-level management personnel of those companies. Bailey (1967), Balian (1982), and Balsley and Clover (1988) stated that mail questionnaires have advantages of standardized wording, no interview bias, respondent privacy, cost and time saving, and convenience, but usually the response rate is low. Thus, the researchers were pleased with a response rate exceeding 32%.

A seven-point Likert scale was used to measure participants' opinions. The seven-point Likert scale was designed as: (1) very satisfied, (2) satisfied, (3) somewhat satisfied, (4) no difference, (5) somewhat dissatisfied, (6) dissatisfied, and (7) very dissatisfied. The frequency of responses for each question was calculated. Means, medians, and standard deviations were executed for the results.

Findings

A total of 27 questionnaires (32.53%) were received out of 83 subjects from 28 states of the United States. Twenty three valid questionnaires were used for the data analysis. Original ordinal data were converted to ratio data as 1 = very satisfied, 2 = satisfied, 3 = somewhat satisfied, 4 = no difference, 5 = somewhat dissatisfied, 6 = dissatisfied, and 7 = very dissatisfied. Table 1, Table 2, and Table 3 show the frequencies of questions on productivity, eco-friendliness, and technical skills needed that were answered by participants. It is observed from the tables that participants' responses varied from "very satisfied" to "very dissatisfied" for productivity, from "very satisfied" to "no difference" for eco-friendliness, and from "very satisfied" to "very dissatisfied" for technical skills needed. A majority of participants responded in the satisfaction range for all three characteristics.

Satisfaction Level	Frequency	Percent	Valid Percent	Cumulative Percent
Very Satisfied	6	26	26	26
Satisfied	9	39	39	65
Somewhat Satisfied	1	4	4	69
No Difference	2	9	9	78
Somewhat Dissatisfied	2	9	9	87
Dissatisfied	2	9	9	96
Very Dissatisfied	1	4	4	100
Total	23	100	100	
Total	23	100		

Table 1: *Frequency of Productivity Satisfaction*

Satisfaction Level	Frequency	Percent	Valid Percent	Cumulative Percent
Very Satisfied	9	39	39	39
Satisfied	7	30	30	69
Somewhat Satisfied	5	22	22	91
No Difference	2	9	9	100
Total	23	100	100	
Total	23	100		

Table 2: *Frequency of Eco-Friendliness Satisfaction*

Satisfaction Level	Frequency	Percent	Valid Percent	Cumulative Percent
Very Satisfied	2	9	9.5	9.5
Satisfied	8	35	38	47.5
Somewhat Satisfied	4	17	19	66.5
No Difference	4	17	19	85.5
Somewhat Dissatisfied	2	9	9.5	95
Very Dissatisfied	1	4	5	100
Total	21	91	100	
No Data	2	9		
Total	23	100		

Table 3: *Frequency of Technical Skills Needed Satisfaction*

The means for productivity, eco-friendliness, and technical skills needed were 2.78, 2.00, and 3.00 (see Table 4) on the seven-point Likert scale respectively. The participants were satisfied overall with three characteristics, but they were more satisfied with eco-friendliness of waterless litho than the other two characteristics, productivity and technical skills needed, in comparison with the same characteristics of conventional litho.

Characteristics	N Valid	Missing	Mean	Median	Standard Deviation
Productivity	23	0	2.78	2.00	1.86
Eco-Friendliness	23	0	2.00	2.00	1.00
Technical Skills Needed	21	2	3.00	3.00	1.48

Table 4: *Statistics for Productivity, Eco-Friendliness, and Technical Skills Needed*

Conclusions

The results of the empirical study showed that though there were mixed opinions among lithographers who had experience with both printing processes, conventional and waterless litho, a majority of them believed they were satisfied with waterless litho as compared to conventional litho on three characteristics, productivity, eco-friendliness, and technical skills needed. The results provide important data for those who want to compare waterless litho with conventional litho on those three criteria.

Recommendations for Future Research Studies

Recommendations are made based on research methodology and findings. The following recommendations are made for future research studies.

1. An experimental study should be conducted to print substrates using both waterless litho and conventional litho under the same settings.

2. A research study should be performed with a larger sample size of printing companies that operate both waterless litho and conventional litho to verify the results, and generalize findings for the larger population.

4. Research should be performed to compare different characteristics of waterless litho, such as, quality, costs, proof matching, ability to print on a variety

of substrates, and training time with those of conventional litho.

5. Research should be performed to compare the overall satisfaction of lithographers with waterless litho against conventional litho.

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This is a referreed article

High Dynamic Range Photography

by Chris Lantz, Western Illinois University

Introduction

High dynamic range (HDR) photography is able to see into the brightest highlights and darkest shadows in direct sunlight. A HDR file is created from multiple exposures made from the same scene. Multiple images with normal, dark, and light exposures are combined into one HDR image in Photoshop CS2 or a dedicated HDR program such as Photomatrix. In the past, HDR was a specialized technique but is becoming more common for a wide variety of subjects with a high brightness range. In addition to pictorial photography, HDR images are used as light maps for 3D modeling applications. For many years, photographers tried to use film to achieve the capabilities of HDR photography. Many black and white films have a dynamic range beyond that of most digital sensors, but they are not able to reproduce the full dynamic range of a sunlit day.

HDR Image Capture

A normal exposure is made and then the shutter speeds are used to underexpose and overexpose usually by one stops increments. The f-stops are not used for bracketing the exposures because the depth of field would change between exposures causing ghosting in the final blended image. The typical minimum range is a normal exposure plus one underexposed or overexposed image. Greater ranges of exposure are necessary depending on the range of tones in the scene. The histogram display and image preview on the camera can be used to determine if any tones are captured at the extreme range of the exposures. With a stationary subject and the camera locked down on a tripod, many photographers shoot the entire range of exposures available to them. The big disadvantage of this method is that the subject and camera must be stationary between exposures or misalignment will occur.

The HDR image is saved in a 32-bit format such as the most common Radiance or Open EXR. Photoshop, Large Document Format, Portable Bitmap, and TIFF are the other options available for 32-bit images in Photoshop CS2. For typical hardcopy and display applications, the HDR file is not a final result. The full range of tones in a 32-bit image cannot be seen on a standard computer monitor or printed. Thus, 32-bit images are an intermediary step to a tone-mapped image. Such HDR image files are also used in 3D modeling applications to create realistic lighting patterns. This process is detailed later in this paper.

Tone mapping is the conversion of the 32-bit image into a low dynamic range LDR 8-bit or 16-bit image that can be printed and displayed on a computer monitor. Another approach to an HDR scene is to use exposure blending. Exposure blending skips the step of creating a 32-bit HDR file and directly blends several exposures into an LDR 8- or 16-bit image. For scenes that must be captured in the same exposure the greater range of tones in the RAW file format can also be leveraged. Current digital camera technology does not produce 32-bit HDR in a single exposure (unless $60,000 or more is spent on the camera) but it does start with a greater range of tones than a JPEG.

Raw File Blending in Photoshop

A raw file is the raw data from the camera sensor. A raw file is proprietary to the camera brand, such a NEF for Nikon. Little image compression or sharpening is done in the camera with a raw file. On the other hand, considerable image processing is done to sharpen and compress tones into a small JPEG file by most point and shoot digital cameras. Unlike the case with most JPEGs, there is usually enough image data in a single raw file to process it into several different densities while maintaining detail. This

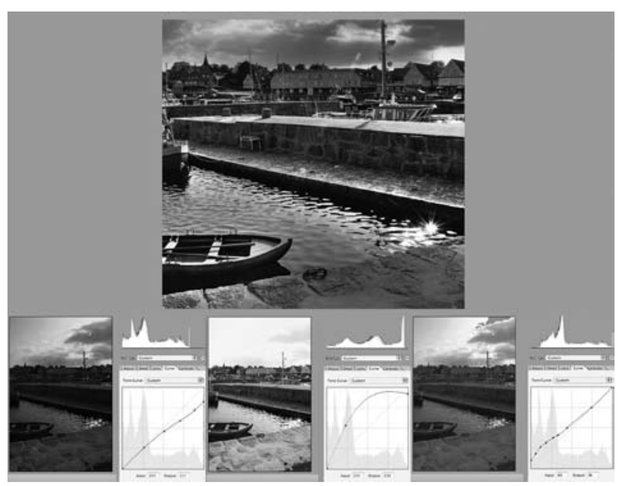


Figure 1- Image blended (top) from several interpretations (bottom) of the same raw file in Photoshop CS2.

technique is important for scenes that must be captured in one exposure to prevent movement between exposures. A single raw file is separately optimized into three files (highlight, midtone, and shadow) and then those files are manually combined with layer masks in Photoshop or with exposure blending functions in Photomatrix. Figure 1 shows the curve shapes necessary to bring up the highlight, midtone, and shadow detail using the curve tab in camera raw. The disadvantage of this method is that the raw file processed for the shadows is often very noisy or grainy.

Exposure Blending in Photomatrix

Photomatrix is a stand-alone Mac or Windows program that can automate the blending process for the separately processed raw images as well as 32 bit HDR functions. At present, it is available as a trial version at $99 for a regular license or $39 for an educational license at **hdrsoft.com**. Exposure blending is accomplished by opening the files and then using the Combine popup option. The Highlight and Shadow-Auto option can be used first to see if an acceptable result is achieved. If further control is needed, then the Highlight and Shadow-Adjust or Highlight and Shadow-Intensive options can be used. Blending Point and Radius controls are provided in the Highlight and Shadows-Adjust Window, as shown in Figure 2. The Blending Point control emphasizes the dark or light exposures and the Radius Control has a similar effect to unsharp masking in Photoshop. Exposure blending can also be used with separate in-camera exposures of the same scene.

Figure 2- Highlights & Shadows-Adjust exposure blending window in Photomatrix

The disadvantage of LDR exposure blending over the 32-bit HDR workflow explained later is that it does not work as well with scenes with the greatest extremes between dark and light tones. Exposure blending of in-camera exposures can be very useful for scenes with a one-stop range of exposures using the Highlight and Shadows-2 images option.

HDR in Photomatrix

Photomatrix can also be used for creating a preliminary 32-bit HDR file and then the file can be tone-mapped to a final 8- or 16-bit LDR result. The different exposures are opened and then the Generate HDR option is selected from the HDRI pop down menu. In Step 1, the images are selected and, in Step 2, a Standard Response Curve is selected. A Calculate Response Curve option is also provided for images that originate from curve-adjusted camera raw files. The result of this process is a Generated HDR 32 bit file which looks high in contrast and appears dark because it contains a range of tones that is beyond the capabilities of the computer monitor to display. The dark and light tones can be viewed separately with the HDR Viewer window. Pointing to the shadows or the highlights in the image will reveal the additional detail of the HDR image in the viewer. Viewing the image in the HDR Viewer helps identify important detail to retain in the tone mapping process (Figure 3).

Tone Mapping is selected in the HDRI pop down menu. The Tone Mapping window contains a preview image and controls. Luminosity controls the overall brightness. Strength provides more detail but also more darkening between highlight tones in images with large highlight areas.

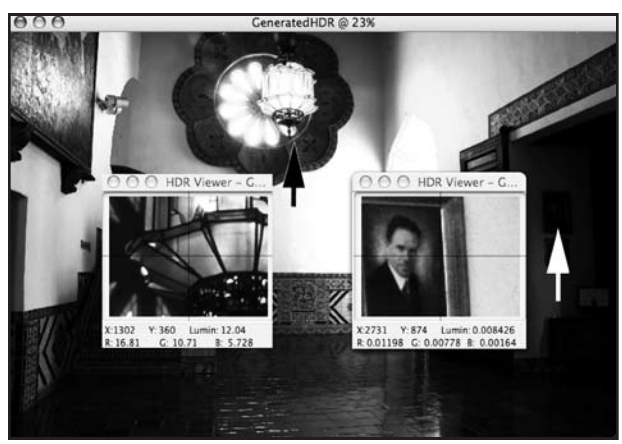


Figure 3- HDR Viewer reveals additional detail in highlight and shadow areas of a HDR file in Photomatrix

White clip brightens light areas and Black clip darkens shadow areas. A High setting for Light Smoothing is often necessary to create a natural blending of tones. A Very Low setting for Light Smoothing almost creates an emboss effect. A Very Low setting for Microcontrast Smoothing brightens many images and a High setting darkens the shadows. A Color Saturation control is provided and some reduction in color saturation is usually necessary. Once finished with the controls in the Tone Mapping window, the image is saved as a JPEG, TIFF, or PNG. Further fine adjustments prefer Photomatrix because it is a more mature program than the HDR features in Photoshop. The Photomatrix tone mapping controls are also provided as filter for Photoshop.

HDR in Photoshop

HDR is a new feature of Photoshop CS2. The separate exposures are selected using the File/Automate/Merge to HDR option. In the Merge to HDR window the files are selected and the Attempt to Automatically Align Source Images checkbox is available for slight misalignment between images. This does not correct misalignment in photos shot by hand-held cameras. Therefore, a tripod is necessary for HDR. The Automatically Align option is useful in correcting slight movement between exposures due to pressing the shutter release button instead of using a cable release. In the Merge to HDR window, the source images are displayed in a row on the left and photos can be removed by using the green checkboxes (Figure 4). The White Point slider provides a starting point for the appearance of the file and is not important because the full range of tones is not viewable at the same time on the monitor with a 32- bit file anyway. The Bit Depth is left at the default 32 bit/Channel.

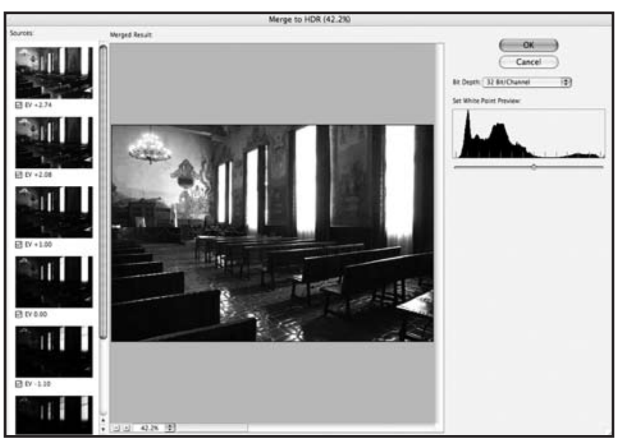


Figure 4- Merge to HDR window in Photoshop CS2

Once the HDR file is open, an exposure slider is provided at the bottom of the image window with the Show/32-bit Exposure option (Figure 5). The exposure slider can be used to darken or brighten the image to see detail in the highlights and shadows. The exposure slider allows the viewer to shuttle through the very large range of tones that cannot be viewed simultaneously on a standard monitor. This does not

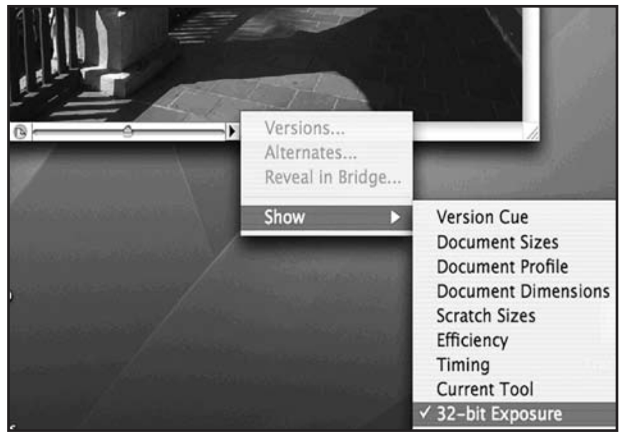
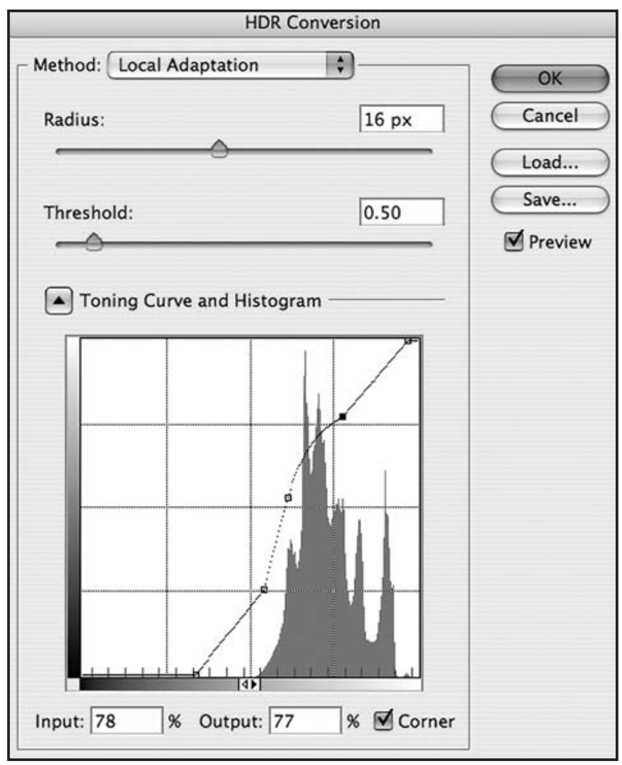


Figure 5- The exposure slider is selected with the fly out menu at the bottom of a 32-bit image window in Photoshop CS2



change the density of the 32-bit file, just the range of tones that are previewed from the 32-bit image.

Very little of the Photoshop feature set is available with a 32-bit photo. In the toolbox, the Clone Stamp is available to remove dust spots. The Smart Sharpen and Unsharp Masking filters are available in 32-bit mode. At this point, the Photomatrix Tone Mapping filter can be used with the same controls as the Tone Mapping window in the stand-alone program. Tone mapping can also be accomplished directly in Photoshop without the optional filter. Tone mapping in Photoshop is done with the HDR Conversion window. The HDR Conversion window only appears when changing the Image/Mode from 32 Bits/Channel to 16 Bits/Channel or 8 Bits/Channel. Four tone-mapping methods are available. No options are available for Highlight Compression and Equalize Histogram methods but their effects can be observed on the image. The sliders in the Exposure and Gamma (contrast) method are easier to use than the Local Adaptation method, but offer less control over the image. Local Adaptation provides control over the Toning Curve and Histogram display at the bottom of the window and is the best option (Figure 6). Points can be added to the curve and a classic s-curve can be used to provide a more natural looking result than the default image that is often flat, low in contrast, and dark. The Threshold slider has a similar effect as unsharp masking and the Radius slider has the effect of increasing the contrast in many images. The corner checkbox can be used to anchor control points to the curve and then make more independent curve shape adjustments between points.

HDR Shop

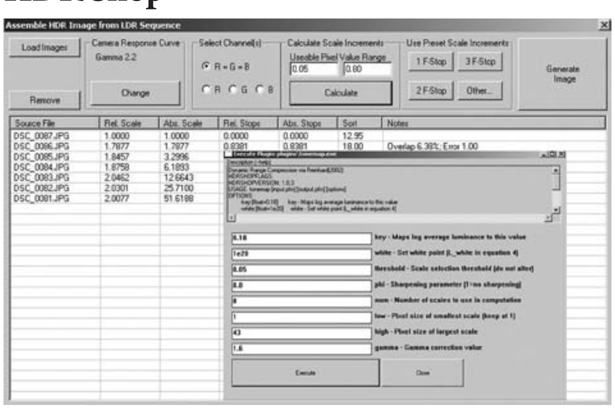


Figure 7- Assemble HDR Image from LDR Sequence and the Reinhard tone map filter windows in HDR Shop

HDR Shop 1.0.3 is a Windows only program copyrighted by the University of Southern California and is available for free downloads at HDRShop.com for educational use only. The educational version of HDR Shop 2 is available for $99. In order to create a tone mapped image, the Reinhard HDR Tone Mapping Plugin for HDR shop must be downloaded (Gregdowning.com/HDRI/Tonemap/reinhard) and put in a plugins folder in the HDR Shop directory. This tonemap filter is available for free download. Use the Assemble HDR from Image Sequence option from the Create pop down menu in HDR Shop. In the Assemble HDR Image from LDR Sequence window, click the Load Images button (Figure 7). Once the images are loaded, click the Calculate Scale Increments button. The range of exposures is then calculated for the files. Push the Generate Image button. The Assembled HDR Image file will then be displayed. The Exposure/Stop Up/Stop Down options can then be selected in the View pop down menu to shuttle through the range of tones that are beyond the capability of the monitor to display simultaneously. The tonemap plugin is selected from the Plugins pop down menu and then the Execute button is pushed (Figure 7). The PluginResult file that results can then be saved using one of the Low Dynamic Range options such as JPEG or TIFF.

HDR in Cinepaint

MacCinepaint is a fork—or offshoot—of the open source Graphic Image Manipulation Program (GIMP) available for download at sourceforge.net as MacCinePaint-0.21-2.1.nativ.dmg.gz. Cinepaint has animation, HDR, and color management features not available in the standard GIMP package. The Bracketing to HDR filter is included when MacCinepaint and the Linux version of Cinepaint are installed. The HDR feature was not available in the 0.16 Windows version of Cinepaint at the time of this writing. Both GIMP and Cinepaint require the installation of the X11 package from the Mac OSX installation DVD.

Use the Bracketing to HDR option in the File/New From pop down menu in MacCinepaint. Select the different exposures from the dialog box. In the Bracketing to HDR window push the HDR button (Figure 8). The Colors/Gamma-Expose option can be selected from the Image pop-down menu to produce the Gamma-Expose window. The Expose slider can be used to shuttle through the full range of tones in the image that cannot be displayed simultaneously on the monitor.

HDR in Photosphere

Photosphere is a user-friendly HDR program that is available for free download at anyhere.com. It is an image browser program for Mac OSX that has a Make HDR function. It also has a tone-mapped preview feature for HDR files so an exposure slider is not necessary to preview the range of tones in a 32-bit HDR file. On the left side of the main program window is the file directory where the location of the different exposures are opened (Figure 9). Image thumbnails of the files are provided. The thumbnails are selected and the Make HDR option is selected from the File pop down menu. The Remove Ghosts and Remove Lens Flare options in the Make High Dynamic Range window are unique features of the program. Lens flare is a common problem in HDR photographs when the light source is included in the scene. Ghosts are also common if people walk through the different exposures and are in different positions. The file that opens is already tone mapped. The tone-mapped preview can be adjusted with the Auto, Local, and Human checkboxes; Auto is usually the best choice. The Save in High Dynamic Range box should be unchecked to save the tone-mapped image in the Save Option window. The TIFF option is selected prior to saving. Photosphere TIFFs often required the least tone and color saturation fine adjustment after tone mapping.

HDR in 3D

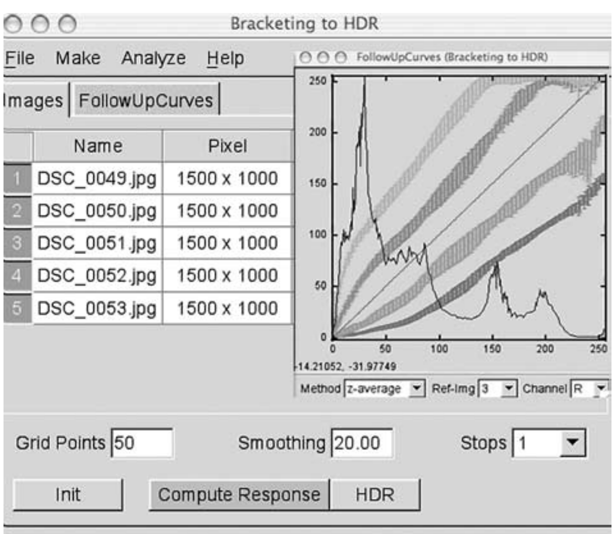


Figure 8- Hartmut Sbosny's open source Bracketing to HDR plugin for Cinepaint

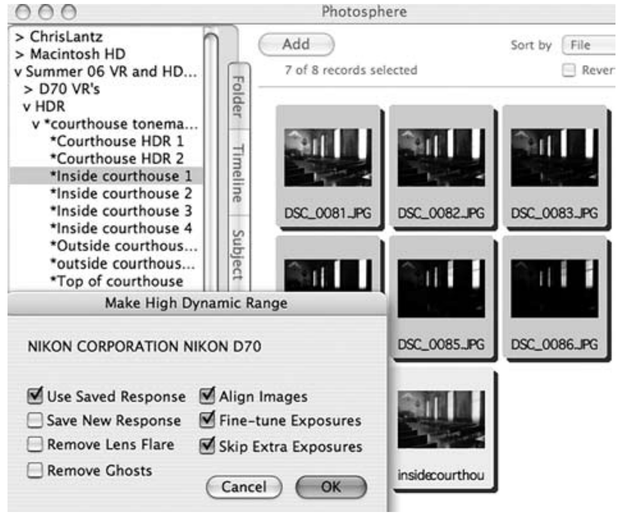


Figure 9- HDR options in Photosphere

In addition to acting as an intermediate step for tone mapping, another application for the HDR file functions as a light map for 3D modeling. Industrial Light and Magic invented the Open EXR (openexr.com) HDR format for such applications. The HDR file is commonly used in Lightwave or Maya because those programs have a long range of tones that make 3D models more realistic. Even lower cost applications, such as Strata 3D and Cinema 4D, can integrate HDR light domes or maps in scenes (Figure 10). HDR images can also be used with the Yafray Raytracer in the open source Blender 3D program. Three-D models are commonly created to integrate with live video footage. The simulated 3D model must be lit in software with the same light as the rest of the real scene. Light maps that are loaded into the 3D modeling program must provide realistic reflections and shadows that blend with the rest of the standard video footage. Such light maps are created using the same HDR software outlined in this paper. One difference is that the files input into the HDR program often need to reflect the 360-degree-surrounding environment in the live scene. This can be done with a light probe. A light probe is a shiny-mirrored ball, such as a gazing ball from a garden, a large ball bearing, or a silver Christmas tree ornament. HDR Shop is able to create a HDR map from such a spherical image. Spherical images can also be unwrapped in software to create a panoramic image with programs such as Cubic Converter at clickheredesign.com. Another higher quality method used to create such a panoramic HDR image map uses a series of bracketed overlapping images. These stills are stitched together to create a panoramic image. LDR versions of these panoramas are used for interactive QuickTime VR

Figure 10- Loading a HDR image map for a lightdome in Strata 3D

movies for web or other multimedia applications. These images are taken while rotating 360 degrees around the live scene. A standard digital camera on a tripod with a special VR tripod head is used. The VR head allows the camera to rotate around at the nodal point of the lens and this provides fewer errors in stitching. Such a head is not necessary if slight stitching errors can be tolerated, such as for educational applications. When HDR is utilized, two or more bracketed exposures are taken at each point of rotation, converted into separate panoramas and are then combined into one final HDR panorama (Figure 11).

Figure 11- Bracketed panoramic images ready to be converted to a HDR file in Photomatrix

Specialized equipment is available for effects houses that produce a large volume of light maps for Hollywood features, animations, commercials, and games. The Spheron Sperocam HDR (spheron.com) is a $60,000 self-scanning HDR camera that can take a panoramic HDR image in one exposure. An LDR self-scanning and single exposure panoramic camera is available for $37,000 (panoscan.com). A HDR monitor that can display the full range of tones in a 32-bit image is made by Brightside Technology (brightsidetech.com) and is available for $49,000.

Future of HDR

HDR is a practical technique to teach a photography class that encounters HDR scenes, such as for landscape or architecture assignments, or for those teaching 3D modeling. The present limitations of 32-bit files and their tone mapping to printable files are also important concepts to introduce in a general graphics applications class. Thirty-two-bit HDR images will become more common in the future as the capabilities of digital cameras and computers improve and the cost of single exposure HDR capture becomes more affordable. The concepts can also be taught with free software and low-end digital cameras.

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This is a juried article.

A Cube Model for Planning Technological Change in the Printing Industry—Influences from within the Industry and External Environment

by Harvey Robert Levenson, Cal Poly State University

This article presents a process for printing industry planning with a view toward technological developments taking place in the industry. Its purpose is to help management understand the role of "growth technologies" and "new technologies" now and in the future. The difference between a growth technology and a new technology will be explained later on.

The premise of this article is that no one should have to make predictions about the future that may influence decision-making based on gut feelings, intuition, incomplete, or inaccurate information. There are methods of planning and devices that allow the organization of thinking and data to enable the most accurate forecasting possible. This paper addresses one such device knowing as "matrix planning." It presents a cube matrix adopted from a two-dimensional planning matrix developed by the Graphic Arts Technical Foundation (GATF) in the 1970s.

Based on readings, interviews, and seminar presentations regarding problems and anticipations in the printing industry, it appears evident that the printing industry needs a systematic process for evaluating its current position and future role in light of developing technologies and other influences on the industry (see references). Some of these influences include alternative forms of media for information, education, and entertainment led by the Internet and World Wide Web, but also including portable devices such as cell phones and PDAs, as well as broadcast and cable television, and even video games.

Cube Model for Planning Printing Company Technology

Most users of print media are not aware that technological developments in science and engineering have created considerable anxiety, anticipation, and frustration within the printing industry. Some of the concerns of printing industry management relate to the potentially changing structure of the industry as a result of the increasing influences of growth technologies and new technologies. A growth technology refers to a technology that may have been in existence for some time, but is currently experiencing considerable growth. A new technology, for the purpose of this report, is one that has been conceived but not yet implemented as a practical application.

For the purpose of illustration, four growth technologies in the printing industry are covered in this paper. Included are variable data printing, gapless blankets, computer-to-press, and electronic paper. Four new technologies are covered. They are atomic switches, camera-to-press, integration among digital presses, and wetware. Any other technology, growth or new, can be plugged into the model. The references for this paper provide details about these technologies.

The implications of growth of these technologies in a practical sense have a bearing on industry parameters and environmental influences that affect printing industry management decisions in an increasingly competitive business. Industry parameters are those that can be controlled within the industry among and within companies. Environmental parameters are those that the industry and those within it have no control over but are at the mercy of. The parameters and influences are considered in view of the growth technologies and new technologies in the proposed cube models.

Industry Parameters Include:

Industry Structure
Markets
Product Form
Internal Technology
Management

Environmental Influences Include:

Social and Economic Conditions
Government Regulations
External Technology
Personnel
International Developments

Growth Technologies Include:

Variable data printing
Gapless blankets
Computer-to-press
Electronic paper

New Technologies Include:

Atomic switches
C-to Technologies
Integration of digital presses
Wetware

For some printing companies, survival in the future may depend on an understanding of the relationships that exist between the growth technologies, new technologies, industry parameters, and environmental influences. These relationships are clearly illustrated in the following three-dimensional cube models.

It is the premise of this paper that if printing industry management can establish an industry profile from analysis, relationships, and analogies drawn from each of the matrix interactions of the cubes, it will have the substance required to build a viable long-range plan based on clearly identifiable assumptions about the total environment of the industry.

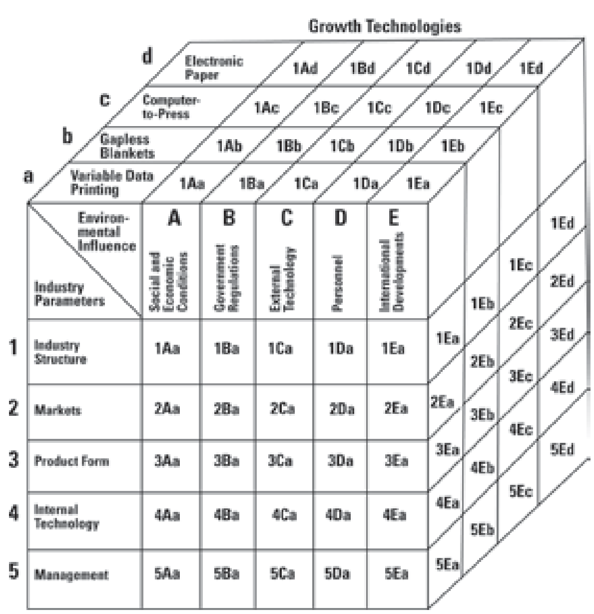
To further enhance the functionality of the cube matrix as a viable process for printing plant management, the following is a description of each industry parameter and environmental influence that may be affected by technological growth. It is followed by a survey of the growth technologies and new technologies used as examples for this article.

Industry Parameters

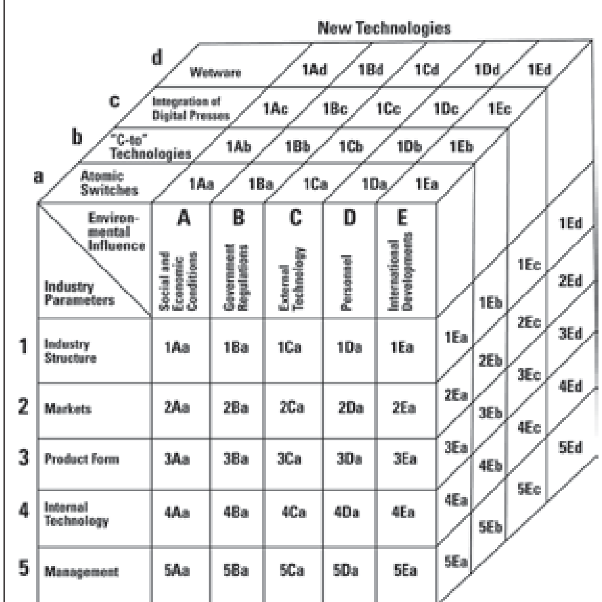
Industry Structure: Includes information on the demographic and economic character of the printing industry. Although most of the concern regarding growth technologies generally relates to the Internet, World Wide Web, and related electronic media, the printing industry is also influenced by many of the same technologies. Variables such as the number of printing plants, geographic distribution, and diversification should be included as part of this parameter.

Markets: Concerns itself with those who use print media or purchase the products of the printing industry. An additional concern of the market parameter is the nature of the relationship between the industry and its

Growth Technologies Model



New Technologies Model



customers and its customer's customers, and any changes foreseen in this relationship.

Product Form: Represents an analysis of the major types of products produced by the printing industry. For example, newspapers and magazines may be a product with news, features, sports, variety and entertainment, special interest articles and, of course, advertising. In this analysis, potentially new product forms, and changes foreseen in existing products, should be examined.

Internal Technology: Relates to the technology in the form of equipment and processes currently and potentially employed by the printing industry in producing its products.

Management: Refers to the management practices and policies employed to maintain a competitive and profitable printing operation.

Environmental Influences

General, Social, and Economic Conditions: Refers to any major shifts in society of relevance to the printing industry. Inflation rates, Gross Domestic Product, population growth, prime interest rates for capital investments, and availability of consumer discretionary spending are all variables having some influence on the direction that the printing industry may take in the future.

Government Regulations: Investigates the various effects of government legislation and regulations pertaining to the printing industry. Of prime concern in the United States, for example, should be the current and anticipated position of the Federal Communication Commission (FCC) as it relates to regulating access to the airwaves, the Securities and Exchange Commission (SEC) as it relates to the printing and distribution of financial, legal, and other security documents, and the Food and Drug Administration (FDA) as it relates to issues of packaging. Other nations would have their own regulatory government agencies to consider.

External Technologies: Refers to the current and potential influences of technological developments outside of the printing industry on the structure of the printing industry. Technological innovations resulting from government-sponsored aerospace and satellite programs related to access to the airwaves, computer sciences, and research in the field of fiber optics and micro-circuitry have had a substantial impact on the printing industry, and can have a greater impact in the future.

Personnel: Assesses the current and potential interaction required between personnel and technology, and the availability of trained staff to handle new printing industry technologies. Significant technological change normally necessitates training. Printing industry management should know whether future qualified personnel will be developed within the printing industry, or whether staff will have to be recruited from other industries.

International Developments: Analyzes the effects of international trade and the products of the international printing industry on the domestic printing industry. Of particular concern to the domestic printing industry of most nations should be the increasingly rapid spread of technological change throughout the developed and developing countries, and the increased investments of overseas companies in domestic markets related to the printing industry, i.e., Japan, Germany, China, India, and others.

After having established the substance for the individual matrix entries, management has the construct for developing theories and concepts resulting from an analysis of the cube matrix relationships. Example of a relationship on the Growth Technologies matrix is the relationship between social and economic condition on product form and the development of Electronic Paper. This would be (3Ad) on the matrix. Another example on the Growth Technologies matrix would be management concerns about the availability of qualified personnel to run variable data printing presses. This would be (5Da) on the Growth Technologies matrix. Indicative of relationships in the context of the New Technologies matrix is the provision for studying the influences of government regulations on product form in view of the feasibility of installing atomic switches to drive printing equipment. On the cube matrix model this would be relationship (3Ba). Another relationship would be the influence of integration of digital presses being produced internationally on markets. This could be analyzed through matrix relationship (2Ec).

From the theories, concepts, and analogies drawn from the cube matrix relationships, printing industry management can formulate, in a systematic fashion, viable objectives concerning the optimum direction that should be taken in the form of investments in technology, staffing, programming, and market development.

Survey of Growth and New Technologies

Growth Technologies

Variable data printing

We hear a lot about variable data printing and, in fact, it has been around in a practical sense for over a decade, first for black and white addressing of magazines and direct mail advertising, and more recently for full-color variable images including versioning where type, picture, and layout can be varied for the individual recipient of print. Until recently, this was a tremendously costly, time-consuming, and difficult process, and in many respects still is. However, cost, time, and difficulty have come down due to exerted efforts on the part of hardware and software developers to make this technology practical and affordable. Many in the industry, and particularly in the direct mail segment, see variable data printing as the savior of print in light of competition with the Internet and World Wide Web where personalized communication is standard. In publication printing it is viewed as the possible future savior of newspapers and magazines. In the future such daily, weekly, and monthly publications may be delivered with variable data of particular interest to the recipient or subscriber. Experiments have been conducted to test the practicality and acceptance of this.

Gapless blankets

This was an incredibly creative technology invented by Harris, moved to Heidelberg, and now owned by Goss International. While conceived in patents years ago, but only along with gapless plates, the technology was actualized on a press with gapless blankets and gapped plates by Harris and became a hallmark feature of the M3000 web press also known as the Sunday Press (because the idea of gapless blankets on a press with gapped plates was conceived on a Superbowl Sunday). This process resulted in the fastest web press in the world (3000 feet per minute), with minimum vibration (no bounce at the blanket gap), an enormous savings of paper waste (about a quarter of inch per revolution), and the fastest blanket changes ever (as little as 20 to 40 seconds). These advantages and efficiencies are seen by the industry as a "must" in the future to address productivity, quality, waste and cost savings, with the latter related to paper.

Computer-to-press

Computer-to-film via filmsetters was considered a phenomenal advancement when this technology emerged in the 1980s. The significance of this was exceeded in the 1990s with the advent and rapid popularity of computer-to-plate, and platesetters, by many companies in the equipment manufacturing sector of the graphic arts. Companies such as Creo, Agfa, Screen, Fuji, and others were responsible for the demise of film for printing production. However, little did industry leaders realize that computer-to-film and computer-to-plate technology were merely rapidly passing technologies on the way to computer-to-plate-on-press and then to computer-to-press. The digital printing press manufacturers showed how this could be achieved. New names, never before part of the traditional printing industry, emerged around the mid-1990s, such as Xeikon, Indigo, Océ, and others. They all demonstrated how imaging could be transmitted from a computer directly to a printing press cylinder, and each revolution of the cylinder can have a different image. Other companies, already in the printing industry, such as Xerox, IBM, Heidelberg, and MAN Roland, picked-up on the computer-to-press concept in their development of digital presses.

Electronic paper

Some may say that electronic paper is a new technology by my definition. However, it is here and being used and will only further develop and grow in the future. Introduced about 10 years ago in two different versions by Xerox's Palo Alto Research Center (PARC) and MIT's Media Lab, this technology is having its impact through the application of Radio Frequency Identification (RFID). The technology generally involves pigmented microcapsules built into the substrate that can be manipulated by electrostatic charges from a remote site. The first practical applications are taking place in the packaging industry where supermarkets are using the concept for instantaneous changes of product prices and promotions in supermarkets. The technology was first promoted as a way of changing text in books so one novel, for example, could be changed to another novel without changing the substrate. There was even talk of being able to re-image daily newspapers or weekly magazines. This may be a long-term application. However, the packaging industry was the first to adopt it in a practical sense. The outdoor advertising industry represents another viable application for changing images on transportation posters and billboards.

New Technologies

Atomic switches

The new technologies that will impact the printing industry in the immediate future will likely be invisible. They will be vast improvements to the internal components of equipment that will enhance speed and accuracy, and miniaturize the internal parts of equipment. Atomic switches are perfect examples of this. The concept was introduced by IBM several years ago and involves switches that use a single atom as its moving part. Using a power supply, short electrical pulses cause a xenon atom to jump between an electrode and a nickel surface. Reversing the voltage causes the atom to jump in the opposite direction, hence, serving as an "on-off" switch. An on-off switch is the basic element of computers and microprocessors that drive technology. The atomic switch has great potential in the printing industry where sensitive processes have to be carried out accurately and quickly.

"C-to" technologies

Now let's take the Computer-to-Press example under Growth Technologies and expand it.

"C-to" technologies used to mean "computer-to" technologies. However, this may no longer be true in the future. As previously noted, in the past it meant "computer-to-film, and more recently it has meant "computer-to-plate", "computer-to-plate-on-press," and "computer-to-press." However, in the near future it may mean "camera-to-press" and at some point beyond that it may even mean "cerebral cortex-to-press." This last example is not too far fetched when considering advances being made in "wetware" described later in this paper.

Looking first at the "camera-to-press" example, with the rapid advances being made in digital photography, it is quite conceivable that the camera can become the vehicle for nearly everything that is done in prepress today. This includes image creating (pictures and text); image manipulation in the form of cropping, color correction, and retouching; layout and pagination; preflighting; and more. With such capabilities, it is not a far stretch for the transmission of images for printing to go directly from a digital camera to the printing press cylinder.

Taking the potential of new technology a step further, and incorporating the concept of on-off switching being the essence of digital imaging, it is not inconceivable, if "wetware" technology continues to develop, that data may go from the brain's cerebral cortex to the printing press. How is this potentially possible? Changes in thought occur as a result of electrical signal impulses in the brain. Each electrical impulse represents an on-off situation analogous to the way digital computers operate. On-off sequences are further analogous to switches as previously noted. Once the brain operates as a switching mechanism for creating signals, and once we learn how to transmit those signals, the concept of "cerebral cortex-to-press" becomes a reality.

Imagine thinking of an image and through electrical signals naturally generated by the brain, the image is sent directly to a digital printing press where 50,000 copies of your thoughts are reproduced in perfect color. (You're laughing at Levenson? Remember, they also laughed at Fulton when he invented the steam engine.)

Integration of digital presses

This is simple compared to the "C-to" example of new technology.

Digital presses are here to stay well into the distant future. However, they presently exist as standalone systems tied into the technology and software of individual companies. The industry will insist that this has got to change in the same way that the industry insisted that standards be developed in the 1980s enabling Color Electronic Prepress Systems (CEPS) to "talk to each other." The industry was making huge investment in CEPS technology and companies did not want to be locked into one company for all of their prepress needs. The same will occur in the digital press arena if the proliferation and investment in such presses will continue to grow. Companies will want digital printing devices from two or more companies with the capability of the devices to communicate with one another. More specifically, Xerox presses will have to "talk" to Xeikon presses, that will have to "talk" to Océ presses, that will have to "talk" to H-P presses, etc.

Wetware

Wetware involves harnessing the power of living, organic, components to build and use technology. The graphic communication industry is entering the realm of uncharted territory in this area. Imagery of human organs, already available, will be further developed in the future by using 3-D and holographic technology developed for use in graphic communication. Also, the near future shows promise of the availability of technology permitting typing with the eyes by merely viewing the characters on the keyboard and by optically controlling a computer mouse curser. Such technology is already in a developmental stage. Additionally, connecting silicon chips to the human brain may even allow controlling computers through the thought process as previously noted regarding "C-to" technology.

Present research is exploring the feasibility of using brain cells to grow microprocessors. Such technology has the potential of building computers that emulate human responses and decision-making as never before. What makes such technology attractive is that biologically based computers, or living cells, consume less power than conventional electronics. Hence, as the future unfolds there will be technology used to build super-computers the size of bacterium; electrical switches with their only moving part being a single atom; machines consisting of just a few thousand atoms, computers built from living brain cells; silicon chips coated with protein that attract neurons to create "on-off" switches; electrical connections between neurons and electronic devices; axons and dendrites that send signal circuits via neurons; retina nerve cells or brain neurons sensitive to light used in computers for sensing color; cameras implanted in the brain as an artificial eye providing vision for people who are totally blind; communication to computers by minimum muscular movement; and communication by thought using the electricity of brain waves.

In conclusion, these are all examples of research presently taking place that will alter the means of media production and communication in ways never before thought possible. The purpose of the cube matrix model interactions is to provide a means for organizing and analyzing growth technologies and new technologies in relation to environmental influences and industry parameters. The proposed method will provide industry forecasters and executives with a means of planning corporate growth and investments in technology.

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Does Access to Communication Technologies Outside the Classroom Have Significance in Student Learning?

by Carl N. Blue, University of Northern Iowa

At a national level, four new communication technology instructional units for the middle and high school classroom were disseminated and field-tested by the TECH-know Project, a program funded by the National Science Foundation (NSF) for the development of instructional materials. These four communication technology units are part of a total of 20 classroom units that were developed over a four-year period. North Carolina State University, the Technology Student Association (TSA), and the Departments of Public Instruction of North Carolina, Florida, Oklahoma, and Virginia were partnered to create, pilot, revise, and distribute student-centered instructional materials that are based on 20 TSA competitive activities (Taylor, 2004). Statistical significance evaluation of the pretest and posttest scores for all four TECH-know Communication Units of Instruction reported a positive affect on student gains. These instructional units were found to be a valuable resource for the inclusion of mathematics, science, and technology curriculums for modern standard-based education programs (Blue, 2006). These standards-based units included:

1) Cyberspace Pursuit, a middle school unit that explores technologies related to the Internet and webpage development.

2) Digital Photography, a middle school unit that explores the technologies and concepts behind electronic imaging.

3) Desktop Publishing, a high school unit that explores technologies related to digital printing.

4) Film Technology, a high school unit that explores the technology behind digital video and concepts for video production.

Research Relevance

Does access to communication technologies outside the classroom have an effect on student learning? This article explores successive research beyond the proven success of the four TECH-know Units (Blue, 2006) to investigate the possible statistical significance of access to communication technologies—such as the Internet, video-computer games, and other digital communications equipment—outside the classroom on middle school and high school students' achievement. For the purpose of this subsequent investigation, this evaluation re-focused on the same four TECH-know Project's communication technology education units of instruction. This inquiry utilizes results from those previous statistical evaluations and incorporates new statistical assessments of a referenced survey of students' access to communication technologies outside the classroom. The objective is to develop a better understanding of the possible connections between students' pre-content knowledge of information and communication technologies.

This research's rationale supports the significance to explore all aspects of the communication technology curriculum as a relevant and valuable resource in preparing students for the future (Robb and Jones 1990). The importance of curriculum development includes the supposition that successful human societies can be defined by their capacity to communicate as well as to create and use technologies that allow people to communicate effectively and efficiently (Haynie & Peterson, 1995). Historically, communication technology curriculum development has been promoted, supported, and rationalized as part of technology education through numerous professional presentations, papers, workshops, meetings, and curriculum efforts (Robb and Jones, 1990). Because communication technologies help us communicate and share information, thoughts, and ideas (Sanders, 1997), it is relevant to investigate how access to communication technologies effects our daily lives, from enabling citizens to perform routine tasks to assisting them in making responsible and informed decisions that will affect individuals, our society, and the environment (ITEA, 2003).

Population of Interest

The population of interest for this study included students in middle school and high school technology education programs that were interested in the communication technology curriculum. In 2005, 20 middle and high school technology education teachers from nine states were provided an intensive one-week professional development workshop on the methodologies and contents of the TECH-know instructional materials. The teachers who were selected had no prior exposure to the materials. States that expressed interest in the field-test included North Carolina, Colorado, Connecticut, Georgia, Mississippi, Pennsylvania, South Carolina, Tennessee, and Wisconsin.

The four field-tested communication technology units incorporated samples from both middle and high school classrooms in five states (Colorado, Connecticut, Pennsylvania, South Carolina, and Wisconsin) in both rural and suburban settings. The communication technology sample included five technology teachers (four males and one female), and a total of 220 middle and high school technology education students. In all, there were eight classrooms that included five high school and three middle school groups.

From the sample of 220 middle and high school technology education students, a sub-group of 132 students participated in the survey (90 high school students and 42 middle school students). There were 44 females and 88 males within the sub-group of respondents. These samples were limited to technology education programs in middle and high school classrooms participating in the TECH-know Project's communication technology education units.

Methodology

The four communication technology units were first measured by an analysis of pretest and posttest of students' content knowledge. Criterion-referenced tests (CRTs) were developed within the course of the TECH-know Project's expert content development and pilot testing phases. The results from that phase of the research were first reported in Fall 2006 issue of the *Visual Communications Journal* in an article entitled: "Middle and High School Curriculum That Addresses Mathematics, Science and Technology Education Standards" (Blue, 2006).

In addition to the CRT data gathered from pretest and posttest scores, additional information was ascertained on students' access to communication technologies outside of the classroom. Frequency data were compiled concerning the participants' responses to 15 survey questions. This information was referenced to the sample's CRT assessment data to determine any statistical significance in their relationship. The research question asked: is there evidence that access to communication technologies outside the classroom has an affect on student scores? For the purpose of addressing this inquiry, analysis of variance (ANOVA) was utilized to evaluate the relationship between the means of the quantitative response variables and a qualitative explanatory variable. In ANOVA, the goal is to determine the reliability of mean group differences. For the exclusive purpose of this ANOVA investigation, the pretest scores would serve as the control group and the posttest scores would serve as the treatment group. Because the control group scores were collected prior to treatment, this group was analyzed for statistical significance for any relationship to the qualitative information about access to communication technologies outside the classroom.

For each of the 15 questions, an ANOVA analysis was performed to evaluate relationships in significant differences in gender, grade level, and among each of the four TECH-know Communications Units. Each control group's ANOVA assessment was compared at an alpha [α] confidence level of 95% and a probability P-value of 0.05. The P-value probability was the primary reported result in these significant tests. (Agresti & Finlay, 1997).

Findings

Significance of communication technologies of interest as revealed by survey responses

Question one asked: do you have the use of a computer where you live? Based on an ANOVA analysis, the question on access to computers was found to have had an influence on the differences in the mean scores of males at the pretest stage. For the male control pretest group sample, where pretest treatment was the factor, the P-value was less than 0.05 (0.0133) rejecting the null hypothesis of no effect. This significance on the question of access to computers at home for males suggested that there was some knowledge at the pre-treatment level to account for this significance of variance to their pretest scores.

The ANOVA test for the female sub-sample for survey question one provided a "non-applicable number" (NaN). This means that in any one of the response categories, one or no response was provided. This caused the ANOVA to return a "NaN," so no quantifiable P-value was processed. Further evaluation and elimination of the non-response category would be necessary to determine an outcome.

However, nearly 85% of the respondents stated they either had access to or use of a personal computer. This quantity is significant if one refers to Bolt and Crawford's 2000 book, *Digital Divide*. They stated that the reality is that a majority of American youths are not up to date with digital tools, and their options may be few. *Digital Divide* looked at the role in which computers are playing in widening socio-economic and educational gaps throughout our society (Bolt & Crawford, 2000). Perhaps, during the years since Bolt & Crawford did their research, access to computers has become more widespread among students of all socio-economic groups. Or, the sample of students who took the pretest may have been skewed because people in technologically intensive school programs may have self-selected based on their interest in technology. This second possibility deserves additional research.

Question two asked: can you go online and surf the Internet where you live? The ANOVA analysis found there was no significant difference found in the data at the pretreatment level. The P-value for the total sub-sample is greater than 0.05 and does not reject the null hypothesis of no effect. However the descriptive statistics stated that nearly 75% of the respondents reported having access to the Internet where they live. These percentages are higher than the national average of 68.7% of Internet users in the United States according to Nielsen//NetRatings reporting as of October 2005 (Population Statistics and Market Data, 2005). This can be noted as a positive attribute since the sample's access to the Internet is above the national average.

Question three inquired: do you know how the computer where you live is connected to the Internet? The ANOVA analysis found there was no significant difference found in the data at the pretreatment level. The P-value for the total sub-sample is greater than 0.05 and, therefore, does not reject the null hypothesis of no effect. However, nearly a third of the respondents reported to have high-speed access to the Internet. This percentage is consistent with the percentage of broadband subscribers in the United States, December 2004, according to Nielsen//NetRatings (Miniwatts, 2005). This can be noted as a positive attribute since the sample's access to high-speed Internet is consistent with the national average.

Question four was: how many hours on average in a day do you go online at school? Respondents reported 16% do not go online at school, 63% went online less than one hour, 12% spent 1–2 hours online, and 6% spent 2–4 hours online a day during school hours. The ANOVA analysis found there was no significant difference found in the data at the pretreatment level. The P-value for the total sub-sample is greater than 0.05. Thus, it does not reject the null hypothesis of no effect.

Question five asked: how many hours on average in a day while NOT in school do you go online by connecting to the Internet where you live from Sunday through Thursday? The high school respondents reported that 19% did not go online, 15% spent less than one hour, 28% spent 1–2 hours, 17% spent 2–4 hours, and 20% spent 4–6 hours online. For the high school control group, where pretest treatment was the factor, the P-value is less than 0.05 (0.0183). Thus, the null hypothesis of no effect was rejected. The question of the amount of time spent online at home on school days had an influence on their differences in mean scores at the pretest stage. The ANOVA analysis found there was significant difference and the amount of time spent online had a significant influence on their knowledge at the start of the program.

Question six asked: do you like playing computer video games? Respondents reported that more than three-fourths of the group liked to play video games. This large majority of the respondents demonstrated the attraction of video gaming on middle and high school students, yet no ANOVA significance was associated with this data. The ANOVA test for the sub-samples responses provided a "NaN."

Question seven was: do you play video games where you live? Respondents reported that well over half of the group played video games at home. This large majority of the respondents demonstrated the attraction of video gaming on middle and high school students, yet no ANOVA significance was associated with this data. The P-value for the total sub-sample is greater than 0.05 and does not reject the null hypothesis of no effect.

Question eight inquired: on what do you play most of your computer video games where you live? Respondents reported that 25% play games online with other players and 40% play games on a TV/DVD game player station. This large majority of the respondents demonstrated the attraction of video gaming on middle and high school students, yet no ANOVA significance was associated with this data. The ANOVA test for the sub-samples responses provided a "NaN".

Question nine asked: how many hours on average in a day while NOT in school do you play computer video games where you live from Sunday through Thursday? Respondents reported that 19% do not play video games, 41% stated less than one hour, 23% played 1–2 hours, and 15% played more than 2 hours a day. For the both the high school and middle school groups, the question of the amount of time spent playing video games at home on school days had an influence on their differences in mean scores at the pretest stage. The ANOVA analysis found there was significant difference in the question of the amount of time spent playing video games at home for the high school and middle school group. This suggested that there was some knowledge at the pretreatment level to account for this significance of variance to their pretest scores. The P-value is less than 0.05 (0.0447), thus rejecting the null hypothesis of no effect.

Both the high school and the middle school groups were tested separately and found to have significance. In regards to middle school students, this significance at the pre-content level is discussed by Dr. James Paul Gee, author of *What Video Games Have to Teach Us About Learning and Literacy* (2003). Gee stated that a young gamer learns resources for future problem solving within this semiotic domain of game playing. According to Gee, video games encourage good principles of learning and make individual learning powerful (Gee, 2003).

Survey question ten was: how many hours on average in a day while in school do you play computer video games? Respondents reported 50% do not play video games at school, 43% stated less than one hour, and 7% stated one hour or more. No ANOVA significance was associated with this data. The ANOVA test for the sub-samples responses for survey question ten provided a "NaN." So, no quantifiable P-value could be processed. Further evaluation and elimination of the non-response category would be necessary to determine an outcome.

Question 11 inquired: do you have a digital camera where you live? Respondents reported that 35% had no digital camera and 65% had access to such a camera. The ANOVA analysis found there was a significant difference on the question of access to digital equipment at home for the all members of the group. This suggested that there was some knowledge at the pretreatment level to account for the significant variance in pretest scores. The ANOVA test for the sub-sample responses provided a P-value less than 0.05 (0.0201), thus rejecting the null hypothesis of no effect.

In question 12, students were asked: do you have a color printer for your digital picture camera or a computer color printer where you live? Respondents reported that 31% had no color printer, 8% had one but no access, and 65% had access to a color printer. The ANOVA analysis found there was significant difference on the question of access to digital equipment at home for all members of the group. This suggested that there was some knowledge at the pretreatment level to account for this significance of variance to their pretest scores. The P-value is less than 0.05 (0.0353), thus rejecting the null hypothesis of no effect.

Question 13 was: do you have a digital video camera where you live? Respondents reported that 43% had no video camera, 11% stated there was one in the home, but they did not have access, 27% had access to a video camera, and 18% had access to a personal video camera. The ANOVA analysis found there was a significant difference on the question of access to digital equipment at home for the members of the high school group. This suggested that there was some knowledge at the pretreatment level to account for this significance of variance to their pretest scores. The P-value is less than 0.05 (0.0019). Thus, the the null hypothesis of no effect was rejected.

In question 14, participants were asked: do you have access to a computer program for editing digital video where you live? Respondents reported that 70% had no access to a computer program, and 30% had access to the software program. Though all participating members of the four TECH-know Communication Technology Units were evaluated, the ANOVA analysis found there was significant difference on the question of access to editing software at home for only members of the Desktop Publishing Unit, with a P-value is less than 0.05 (0.0003) (rejecting the null hypothesis of no effect). This analysis suggested that there was some knowledge at the pretreatment level to account for this significance of variance to their pretest scores as compared to students enrolled in courses offering the other three communication technology units.

Question 15 asked: do you think if students had access to communication technologies at home like the technologies students have in the classroom, they would do better in school? The greater majority (70%) of students felt that access to communication technologies in the home would benefit their education. In an analysis for the relationship of ANOVA significance, this question's content had no influence on their pre-treatment knowledge.

Conclusions and Recommendations

It was the goal of this research to investigate any observable connections between students' pre-course knowledge of the content of the four TECH-know Communication Units of Instruction and their access to information and communication technologies. For the purpose of this evaluation, analysis of variance (ANOVA) tests were performed to achieve a better understanding of pre-content knowledge and access to communications technologies at home and at school.

A portion of this research found that students with access to computers outside the classroom demonstrated a significant relationship between their pre-content knowledge and understanding of the communication technology curriculum. Additionally, nearly 75% of the respondents reported having access to the Internet where they live, higher than the national average. The amount of time spent by students online demonstrated a significant relationship between their pre-content knowledge and comprehension of communication technology curriculum. Would further research into access to computers and the Internet outside the classroom offer similar significance of in other areas of curriculum development?

When surveying the influence of computer video games, respondents reported that more than three-fourths of the group liked to play video games and well over half of the group played video games where they live. The amount of time spent playing video games demonstrated a significant relationship between students' pre-content knowledge and their comprehension of communication technology curriculum. This significance on the question of amount of time playing video games at home for the high school and middle school group suggested that there was some knowledge at the pretreatment level to account for this significance of variance to their pretest scores. Does this data agree with Dr. James Paul Gee, author of *What Video Games Have to Teach Us About Learning and Literacy* (2003)? According to Gee, video games encourage good principles of learning and makes individual learning powerful (Gee, 2003). These findings on high school and middle school students playing video games deserves a more detailed study and offers an opportunities for more research into the areas of video games as an influence on student scores. Would further research into access to computers and video gaming outside the classroom offer similar significance of in other area of curriculum development?

Access to digital cameras, color printers, digital video cameras, and video editing software was also studied. Respondents who reported access to these communication technologies demonstrated a significant relationship between their pre-content knowledge and understanding of the communication technology curriculum. This observation is less significant since it could be presumed that access to these technologies would afford greater conjecture. Yet, would further research into access to these and other communication technologies outside the classroom offer similar significance of in other area of curriculum development?

When students were assessed on their views related to access to communication technologies at home similar to those technologies students have in the classroom, the majority (70%) of students thought that access to communication technologies in the home would benefit their educations. Is this view of access limited to students in America, or are there more global observations? In a study conducted in 1993, Jerry Komia Domatob, from Ohio University, examined the perceptions of Sub-Saharan African academic institutions, government agencies, and business officials on their views of new communication technologies for educational and economic development. He found that: all groups observed were optimistic about the positive impact of new communication technologies on training, education, and rural development; that 85% of government and business had positive views; and 78% of academics felt if will be helpful in education and training (Domatob, 1997, p. 64). Because communication technologies help us communicate and share information, thoughts, and ideas, the relevance of communication technology research cannot be limited to one population. A successful human society is reflected by their ability to communicate. The quality of that communication depends upon the creation and use of effective and efficient technologies that enable the general public to perform tasks that assist them in making responsible and informed decisions that affect all individuals, their society, and environment.

Nearly 85% of this study's respondents stated they either had access to or use of a personal computer. This large majority conflicts with Bolt and Crawford's findings in their 2000 book, *Digital Divide*, in which they stated that a majority of American youths are not up to date with digital tools, and their options may be few (Bolt & Crawford, 2000). The sample of students who took the pretest in the present study may have been skewed because people in technologically intensive school programs may have chosen to take communications technology courses based on their interest in technology. This second possibility deserves additional research. For example, the present study could be replicated using as a population students who are not enrolled in communications technology courses. Their responses could then be compared to those of students who are enrolled in such classes.

Additional inquiries into access to digital technologies are recommended for future research. Communication technologies are in a constant state of evolution and greater convergence. Throughout the history of developing civilizations, communication has been the key to their transformation and advancement. Communication technologies evolve to serve the needs of new generations and the negative and positive implications of these new technologies must be addressed and understood. Research and development of curriculum materials in communication technologies benefits the future of student learners and guides the direction of curriculum developers. Our ability to use, manage, and understand communication technologies will depend on a capacity to share information. To better understand that future begins in the development of sound, quality instructional materials that include communication technology curriculum.

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Printing Industry Guidelines for Print Students Part Two: Printing Process Control and Color Separation

by Jerry J. Waite, Ed.D., University of Houston, Don Hutcheson, GRACoL Committee Chair

Abstract

SNAP, GRACoL, SWOP, and FIRST are guidelines for printers and graphic designers. As these guidelines become established in industry, customer service professionals, technical sales representatives, and technicians will be called upon to effectively explain and interpret the guidelines to graphic designers. Meanwhile, print technicians must effectively reproduce guideline-compliant documents. This literature review builds upon a companion paper entitled *Printing Industry Guidelines for Print Students Part One: Guideline Overview and File Format Considerations* (Waite, 2006). Part One introduced the guidelines and focused on file format considerations. This paper focuses on using the guidelines for process control and color separation.

Introduction

Beginning in 1984, high-volume printers—those who print large quantities of products by gravure, flexography, and web offset (particularly publications printers)—banded together and formulated documents that provided guidelines for both designer and printer. In theory, if the designer and printer follow the guidelines, the final product will appear as desired by the customer. These guidelines were gradually introduced and, in many cases, are now demanded by printers. Incoming files that do not meet the guidelines may be rejected.

Encouraged by the apparent success of high-volume printing process specifications, commercial printers are in the process of formulating their own guidelines. Once these guidelines are validated, files for short-to-medium run printing jobs may have to comply with them.

By 2005, four well-researched and widely disseminated guidebooks had been published by industry groups. *Specifications for Web Offset Publications* (SWOP) provides "specifications for everyone involved in graphic arts workflow, which includes all forms of magazine advertising and editorial input, whether analog or digital" (SWOP, 2005). For the most part, printers using the gravure printing process also abide by—and expect compliance to—SWOP. SWOP can be obtained at **http://www.swop.org**.

The *Specifications for Newsprint Advertising Production* (SNAP) are intended for "advertisers, advertising agencies, publishers, pre-press managers, material suppliers, and commercial and newspaper printers" (Newspaper Association of America, 2000). These guidelines are applicable to newspapers and advertising inserts printed by offset lithography, direct lithography, letterpress, and flexography. SNAP can be obtained at **http://www.naa.org/artpage.cfm?AID=1451&SID=214**.

The Flexographic Technical Association publishes *Flexographic Image Reproduction Specifications and Tolerances* (FIRST) (Flexographic Technical Association, 1999/2003). FIRST focuses primarily on the production of packaging using the flexographic process on film, corrugated board, paper, and paperboard. FIRST may be obtained at **http://www.ftastore.com/store/**.

The *General Requirements for Applications in Commercial Offset Lithography* (GRACoL) is "...a document containing general guidelines and recommendations that could be used as a reference source across the industry for quality color printing" (IDEAlliance, (2001). GRACoL helps print buyers, designers, and specifiers work more effectively with commercial printing suppliers. GRACoL can be obtained at **http://www.gracol.org/**.

Guidelines Impact Graphics Instruction

Teachers and professors of graphic communications technology must make constant adaptations to their curricula in order to keep up with the printing and publishing industry. Process camera work, film retouching, and stripping were fundamentals of graphic communications courses less than 20 years ago. Ten years ago, page layout, scanning, image editing, color separation, imagesetting, imposition, and analog platemaking were curricular musts for graphic arts classes. Today, due to fundamental shifts in print workflow and the introduction of industry-approved guidelines, students of print must learn how to shepherd guideline-compliant jobs through the printing workflow. In addition, students must also learn how to bring a company's printing process under control, measure the results, and provide the outcome to graphic designers in the form of a custom or generic International Color Consortium (ICC) profile.

Purpose

The purpose of this paper is to review the literature related to printing industry guidelines, extract from those guidelines essential elements that students of print production and management must learn, provide an overview of hardware/software solutions that can be used by graphic arts teachers to prepare their students for roles in the contemporary printing and publishing industry, and recommend further study. This paper is one of three related papers. *What to Teach Graphic Design Students About Printing Industry Guidelines* (Waite, 2006) focuses on preparing graphic design students for guideline-centric print workflows. The second paper, *Printing Industry Guidelines for Print Students Part One: Guideline Overview and File Format Considerations* (Waite2006), focuses on identifying the guidelines published by the printing industry's niches: web offset publication, newspapers, commercial offset printing, and flexography. In addition, it details file format considerations recommended by each of these four groups. This paper highlights process control methods recommended by the guidelines and how process control impacts color separation techniques.

Members of the committees promulgating the guidelines provided extensive input to this paper. Special thanks are due to GRACoL Committee Chair, Don Hutcheson, and Joseph Marin, senior prepress technologist for Printing Industries of America/Graphic Arts Technical Foundation for the inordinate amount of time they spent insuring that the content of this paper is both accurate and timely.

What Students of Print Need to Know

Because of the increasing emphasis on industry-sponsored guidelines, it is vital for students of print to know, understand, and be able to explain those guidelines to a wide variety of people. Printing company sales support individuals, such as customer service and technical sales representatives, will be increasingly called upon to explain and interpret industry guidelines to graphic designers so that files can be prepared correctly from the outset. On the other hand, printing company technicians' roles will change so that they will primarily be responsible for: 1) creating and disseminating company-specific specifications—such as ICC Color Profiles—that graphic designers must have in order to do their jobs; 2) preflighting incoming PDF/X-1a documents to make sure they meet the proper guidelines; and 3) imposing, trapping, RIPing, proofing, and outputting guideline-compliant jobs to plate or digital press.

Why Teach Industry Guidelines?

Members of the GRACoL Committee were asked, through an e-mail-based survey, to identify the most important thing about GRACoL that they think college students preparing for careers in graphic communications should know about (Waite, 2006). Several themes permeate their comments. First is the issue of communication. Guidelines facilitate communication and understanding between client and printer. A second theme is consistency and stability. Using SWOP guidelines, for example, a designer can create one set of files for an ad to be produced in numerous magazines that adhere to SWOP. Of course, another set of files would be required for a newsprint reproduction of the ad. However, a different file would not be necessary for Magazine A, Magazine B, and so forth. Consistency is also valuable for the printer: files created to specifications need not be extensively "tweaked" on press. A third theme is control. If file content conforms to guidelines, presses can be kept under control, makeready times can be shortened, and costs reduced. Control requires aim points: ink density, ink color, tonal value increase, print contrast, gray balance, print density curve, highlight range, and so on. Guidelines provide cooperating printers with such aim points.

Which Guidelines Should Print Students Learn?

Instructors of print should procure, read, understand, and teach the relevant guidelines that correspond to the industry segment(s) in which their students will be employed. For example, students being prepared for jobs in web offset or gravure plants should learn SWOP. Commercial printers are adopting GRACoL, newspapers use SNAP, and flexographic plants make use of FIRST.

Instructors and professors should evaluate the local industry and make sure that the guidelines relevant to predominant printers are taught.

The remainder of this literature review covers process control guidelines recommended by SWOP, SNAP, GRACoL, and FIRST. In addition, guideline-compliant classic and colorimetric process control, color separation, and device profiling are reviewed. *Printing Industry Guidelines for Print Students Part One: Guideline Overview and File Format Considerations* (Waite, 2006) provides an overview of the guidelines, the PDF/X-1a file format they recommend or specify, and methods for shepherding PDF/X-1a files through a contemporary workflow.

Print Process Control

The most important contributions that printing industry guidelines provide are process control parameters. These parameters include specification of the actual colors of CMYK inks (ISO 2846 series of standards); target values for solid ink density (SID), print contrast (PC), and tonal value increase (TVI; traditionally known as dot gain); as well as line screen (LPI) and total area coverage (TAC) values. Print process control based on SID and TVI can be referred to as classic process control.

Colorimetric Process Control

With the release of GRACoL 7 in 2006, process control parameters began to move from classic density-based metrics (which measure physical performance but not necessarily visual appearance) to colorimetric-based values that more closely control actual print appearance. For example, the four separate TVI values traditionally measured for C, M, Y, and K are being replaced by calibrating the press (or proofing system) to a precise print density curve (PDC) and controlling the press by measuring two new metrics known as highlight range (HR) and gray balance (GB) in addition to classic SID measurements. The two primary measurements of HR and GB are faster, easier, and more effective than the class process control approach. To ease the transition from classic densitometric press control to the new colorimetric approach, HR and GB aims are defined both in colorimetric CIE L*a*b units and equivalent status T densities. Following GRACoL's lead, SWOP, FIRST, and SNAP may move in a similar direction to meet the greater expectations of color-savvy printers and print buyers.

Process Control and Color Separation

When using the classic approach, a printing company printed a series of test images using standard CMYK inks so that the SID, PC, and TVI measurements on the press sheet matched those in the appropriate guideline. Then, color measurements were taken using either hand-held or automated spectrophotometers. The resulting measurements were then provided, along with LPI and TAC parameters, to graphic designers to be used in *Photoshop's* Custom CMYK dialog box (see Figure 9) when separating color images into CMYK.

In more recent years, the Custom CMYK dialog box as been supplanted by the use of International Color Consortium (ICC) profiles. An ICC profile considers approximately one hundred times more information about the printing process when compared to *Photoshop's* Custom CMYK method. Therefore, CMYK separations created using the Custom CMYK dialog box cannot compete with the quality of those made using a good ICC profile. To make an ICC color profile, specialized software and a hand-held or scanning spectrophotometer are required. The software creates a specific test image that is carefully printed using a proofing device or press. Then, the printed image is measured with the spectrophotometer and the measurements are related by the software to a reference standard that is based on human vision. The resulting comparison is saved in a special file, known as an ICC profile, and can be used by *Photoshop* and other graphic-related programs to accurately convert images to CMYK. Due to the inherent superiority of ICC profiles, all instruction that touches on CMYK conversion should actively discourage the use of *Photoshop's* Custom CMYK box. Instead, ICC profiles should be generated and/or used.

Printers who implement *GRACoL 7* will carefully print test sheets using standard CMYK inks and calibrate their presses so that the SID, PDC, HR, and GB measurements on the press sheet match those in the appropriate guideline. The heart of *GRACoL 7* is a standardized *characterization data set* (CDS) that precisely describes the intended appearance of a press sheet printed to the appropriate specification. If a press is calibrated appropriately, the CDS should describe that press with good precision. This effectively eliminates the need for printers to create ICC profiles for their own presses. So long as a press is calibrated to the appropriate CDS, a generic ICC profile created for that CDS will produce accurate CMYK separations. Adobe has shown strong support for standardized profiles generated from research initiated by printing industry committees. For example, its U.S. Web Coated (SWOP) v2 profile was generated from SWOP's American National Standards Institute/Committee for Graphic Arts Technologies Standards TR001 characterization data (SWOP Incorporated, 2005). Similarly, Adobe has agreed to generate default profiles for *GRACoL 7* when appropriate characterization data are released. These profiles will appear automatically in the recommended profiles list in future versions of applications like *Photoshop*.

A compilation of many printing industry process control parameters, courtesy of PIA/GATF, is shown in Table 1. Table 1 includes SWOP, SNAP, and GRACoL 6 guidelines but does not include those recommended in FIRST. There are numerous variables inherent in flexographic printing. So, instructors and professors who work with students planning to enter the flexographic industry should obtain a copy of FIRST and share its numerous tables with their students. The new colorimetric specifications in GRACoL 7 were being finalized when this paper was written, but were scheduled to be available in 2006 from **www.gracol.org**.

(*Note: Process Controls Primer* (Marin, 2005a) is an excellent resource for instructors and professors wishing to become conversant with print process control. It is available from **www.gain.net**.)

Color Separation and PDF/X-1a

Printing industry guidelines either require or recommend that files be transferred from graphic designer to printer in the PDF/X-1a file format. Since the PDF/X-1a file format *requires* images to be separated into CMYK *before* a compliant PDF is made, *it is imperative* that the

Print Characterization Chart

SUGGESTED Input Variables							Output Print Characteristics							
Paper/ Substrate	LPI= Line Screen	TAC= Total Area Coverage	SID= Solid Ink Density				PC= Print Contrast				TVI= Total Dot Gain %			
			K	C	M	Y	K	C	M	Y	K	C	M	Y
Grades 1 and 2 premium gloss/dull coated	175	320%	1.70	1.40	1.50	1.05	40-45	35-40	35-40	30-35	22	20	20	18
Grades 1 and 2 premium matte coated	150-175	300-320%	1.60	1.30	1.40	1.00	40-45	35-40	35-40	30-35	24	22	22	20
Premium text and cover (smooth)	150-175	260%	1.30	1.15	1.15	0.90	35-45	30-40	30-40	25-35	26	22	22	20
Grade #3 coated	150	310%	1.65	1.35	1.45	1.02	45	40	40	35	22	21	22	18
Grade #5 coated (SWOP)	133	300%	1.60	1.30	1.40	1.00	35-45	30-40	30-40	25-35	22	20	20	18
Supercal SCA+	133	280%	1.50	1.25	1.35	1.00	23	21	21	20	28	26	26	24
Supercal SCB	120	240-260%	1.35	1.10	1.15	0.95	20	19	19	18	28	26	26	24
Uncoated offset	110	240-260%	1.25	1.00	1.12	0.95	20	17	16	17	28	26	26	24
Newsprint (SNAP)	85	240%	1.05	0.90	0.90	0.85	16	13	12	15	30	30	30	30
Newsprint (heatset)	100	240%	1.20	1.08	1.15	0.95	16	13	12	15	32	32	32	32

Figure 1- Image blended (top) from several interpretations (bottom) of the same raw file in Photoshop CS2.

appropriate ICC profile be provided or specified by the printing company and selected by the designer *prior* to color separation. While is it the responsibility of the designer to select and use the correct ICC profile, it is the responsibility of the *printing company's personnel* to specify an approved profile.

Recommended Instruction

To teach students to bring the printing process under the control envisioned by the printing industry guidelines, a multi-step approach must be taken during instruction. The specific type of instruction depends on whether the classic (SID, TVI) process, or the *GRACoL 7* (PDC, HR, GB) process is being taught.

Classic Process Control Instruction

Students must learn how to control and measure every device in the print workflow. In particular, they need to learn to:

1. color-calibrate and create an ICC color profile for their monitors;
2. linearize an image- or platesetter; output linear CMYK test plates;
3. print the linear test plates on the appropriate paper to the SIDs suggested for the type of paper and ink color being used and then measure the resulting TVI values;
4. build a compensation curve for the imagesetter or platesetter so that it, in conjunction with the press, will provide the TVI values suggested by the appropriate guideline for the ink color and paper used;
5. image new CMYK test plates utilizing the compensation curve;
6. print new CMYK test sheets that meet both the appropriate SID and TVI targets;
7. manually or automatically analyze an ICC-compatible characterization target on the test sheet;
8. provide the analysis, in the form of a custom ICC profile or a default ICC profile (such as U.S Web Coated (SWOP) v2) to the graphic designer for use in color separation processes; and
9. calibrate (and/or profile) the digital proofing system to match the same specification.

Colorimetric Process Control Instruction

While most of the steps involved in colorimetric process control are the same as those followed in classic process control, there are some important difference. Students must learn how to:

1. color-calibrate and create an ICC profile for their monitors;
2. adjust a platesetter to the manufacturers' specifications without applying a calibration curve;
3. output *un-curved* CMYK test plates; print the *un-curved* test plates on the appropriate paper to the SIDs suggested for the type of paper and ink color being used;
4. measure the resulting PDCs from a gray-balanced CMY scale, and from a K-only gray scale;
5. build compensation curves for the platesetter so that the final printed sheet matches the PDC suggested by the appropriate guideline;
6. image new CMYK test plates utilizing the compensation curves;
7. print new CMYK test sheets that meet both the appropriate SID, HR and GB targets; analyze an ICC-compatible characterization target on the test sheet;
8. provide the analysis, in the form of a custom ICC profile or the appropriate default ICC profile (such as U.S Web Coated (SWOP) v2) to the graphic designer for use in color separation processes; and
9. calibrate (and/or profile) the digital proofing system to match the same specification.

Calibrating Computer Monitors

Before *any* color work is evaluated or prepared for output, the computer's monitor must be calibrated.

Figure 1. An external monitor calibrator

Macintosh and PC operating systems offer visually-controlled calibration routines. However, these routines, by their nature, rely on the visual acuity of the operator. Therefore, it is preferable to use a monitor calibrator such as the one shown in Figure 1. These devices, along with the appropriate software, make multiple measurements of the monitor's rendition of red, green, and blue light as well as intermediate colors, grays, and black. The measurements are stored on the computer's hard drive in an ICC Profile that will then be available for use throughout the print workflow.

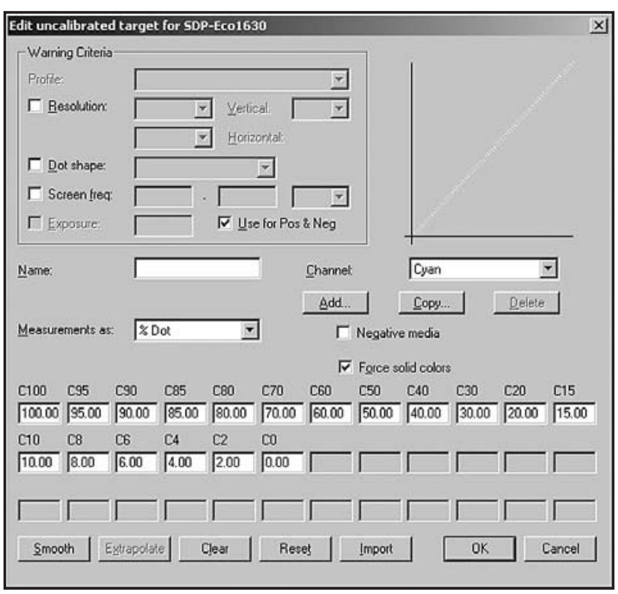


Figure 2. *Harlequin RIP* Edit Uncalibrated Target dialog box

Linearizing Image- and Platesetters for Classic Process Control

One of the goals of printing industry process control parameters, such as those shown in Table 1, is to standardize the TVI (or dot gain) from press to press. In order to accomplish this task, printers need to know exactly the impact of each of their presses on TVI. To assess the influence of a given press on TVI, a set of CMYK plates must be made in which a nominal 25% dot in the imaged file results in a 25% dot on the plate, a nominal 50% dot measures 50% on the plate, and so on. This sort of plate is called *linearized* because there is a one-to-one correspondence between the nominal dot size and imaged dot size. To image a linearized film or plate, a test form consisting of patches of dots that match the Raster Image Processor's (RIP's) calibration targets is output. For example, the Harlequin RIP's Edit Uncalibrated Target dialog box, shown in Figure 2, has fields for 0, 2, 4, 6...90, 95, and 100 percent dots. Using a dot meter or densitometer, the actual dot size produced on the plate or film in each of the patches is measured. Then, the measured reading is input into the field of the Edit Uncalibrated Target that corresponds to the measured patch. The RIP will then build a compensation curve to bring the measured values in line with the nominal ones. Afterward, the same image is again output to film or plate, the dot patches measured, and a comparison of the nominal dot size and measured dot size is made. Recalibration may be necessary until all the nominal and imaged dot sizes agree.

Calibrating Imagesetters and Platesetters for Colorimetric Process Control

The goal of *GRACoL 7's* process control parameters is to standardize the PDC so each press or proofing system produces the same visual contrast and density from the same CMYK data—at least in lighter tones. In order to accomplish this task, printers need to first measure the *natural* PDC of their presses. To assess the natural PDC, a set of *un-curved* CMYK plates must be made in which platesetter's settings, such as focus and exposure, are calibrated to meet repeatable manufacturer specifications. In some cases, this will result in a nominal 50% dot in the imaged file measuring 50% on the plate. However, a one-to-one correspondence between the nominal dot size and imaged dot size is not strictly necessary at this stage. If desired, a single 50% correction point may be entered in the RIP, with all other points either left blank (if

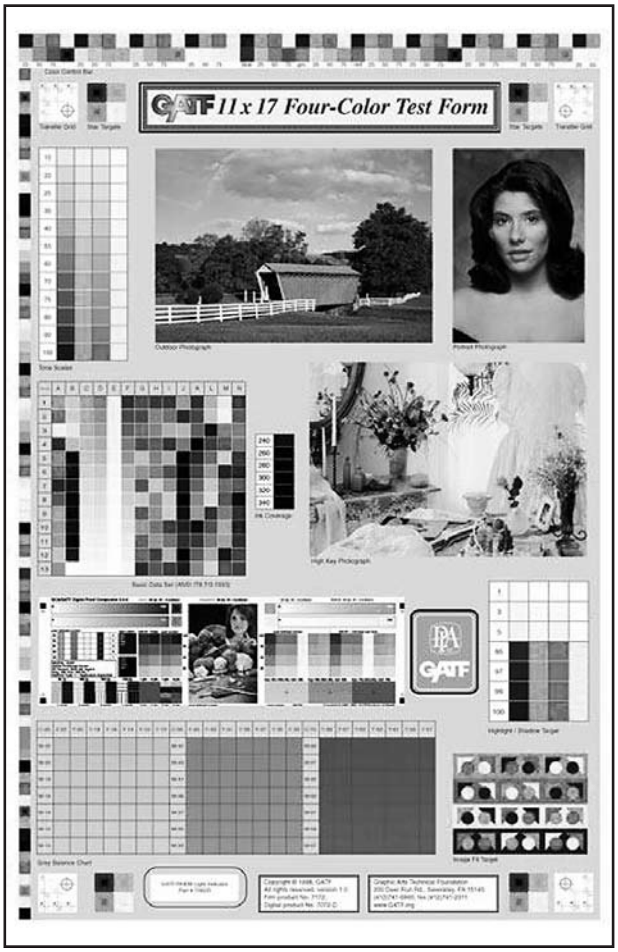


Figure 3. GATF 11 X 17 Four-Color Test Form

the RIP auto-interpolates) or with other points filled with values derived from the 50% correction. For example, if the 50% patch was increased by 3%, the 25% and 75% points would receive manual 1.5% increase values.

Whether the 50% point is adjusted or not, this sort of plate is called *un-curved* because it has effectively no calibration curve yet. Therefore, it should be free from any quantization (banding) or other anomalies introduced by correction points. (Note: if the plate is imaged from film, the film setter should be linearized as described in the classic approach above.)

Outputting Linear (Un-Curved) CMYK Test Plates

Once the image- or platesetter has been linearized (classic approach) or calibrated (colorimetric approach), a set of CMYK test plates must be made. Test plates for classic process control must include patches of CMYK dots so that the printed dot sizes can be measured. If colorimetric process control is to be employed, the test plate must contain a suitable CMYK characterization target from which an ICC profile can be built. Recommended targets at the time of this writing include the IT8.7/4 (CGATS), the ECI 2002 (supplied with most profiling software), or the Hutch2052 target (free at **www.hutchcolor.com**). Actual target choice will depend, among other factors, on the intended profiling software. Whether classic or colorimetric process control is used, the line screen (LPI) used must match the appropriate row of the Print Characterization Chart (summarized in Table 1, but available in greater detail in SNAP, GRACoL, SWOP, and FIRST). An example of an appropriate test image is shown in Figure 3. The GATF Four-Color Test Form, available from **www.gain.net** comes in a variety of sizes to match most printing presses. An equivalent GRACoL test form is available from **www.gracol.org**. If colorimetric process control is being used, the test form should include a Press2Proof target (free at **www.hutchcolor.com**) (Figure 4) or equivalent target for analyzing Neutral Print Density (NPD) Curves. Both GRACoL and SWOP test forms include suitable NPD targets.

Printing Test Plates

Once the test plates have been made, they must be printed using paper from among those listed in Table 1. In addition, it is strongly advised to use only ISO-standardized CMYK inks. The International Standards Organization has specified worldwide CMYK ink colors through its ISO 2846 series (International Standards Organization 1997–2005). Subpart 1 (ISO 2846-1) was promulgated in 1997 and covers sheetfed and heat-set web offset lithographic printing. Subpart 2 (2000) specifies coldest offset lithographic inks; Subpart 3 (2002) specifies gravure inks; Subset 4 (2000) is for screen printing inks; and Subset 5 (2005) covers flexographic inks. ISO "2846 defines the color of the ink in the can via a special test" (L. Warter, Fuji, Inc., e-mail communication, May 24, 2005). Since the printed color depends on many factors—such as paper absorption, ink density, ink contamination, and so on—there are no standards for printed inks. To control as many of these variables as possible, and to get an accurate picture of the effects a press causes to TVI or PDC, it is essential to run each ink's *dry* density to the value specified in the Process Control Characterization Chart (see Table 1 or the appropriate table in SNAP, GRACoL, SWOP, or FIRST).

The most commonly used ink color sequence on a four-color press is black, cyan, magenta, yellow (KCMY). If a

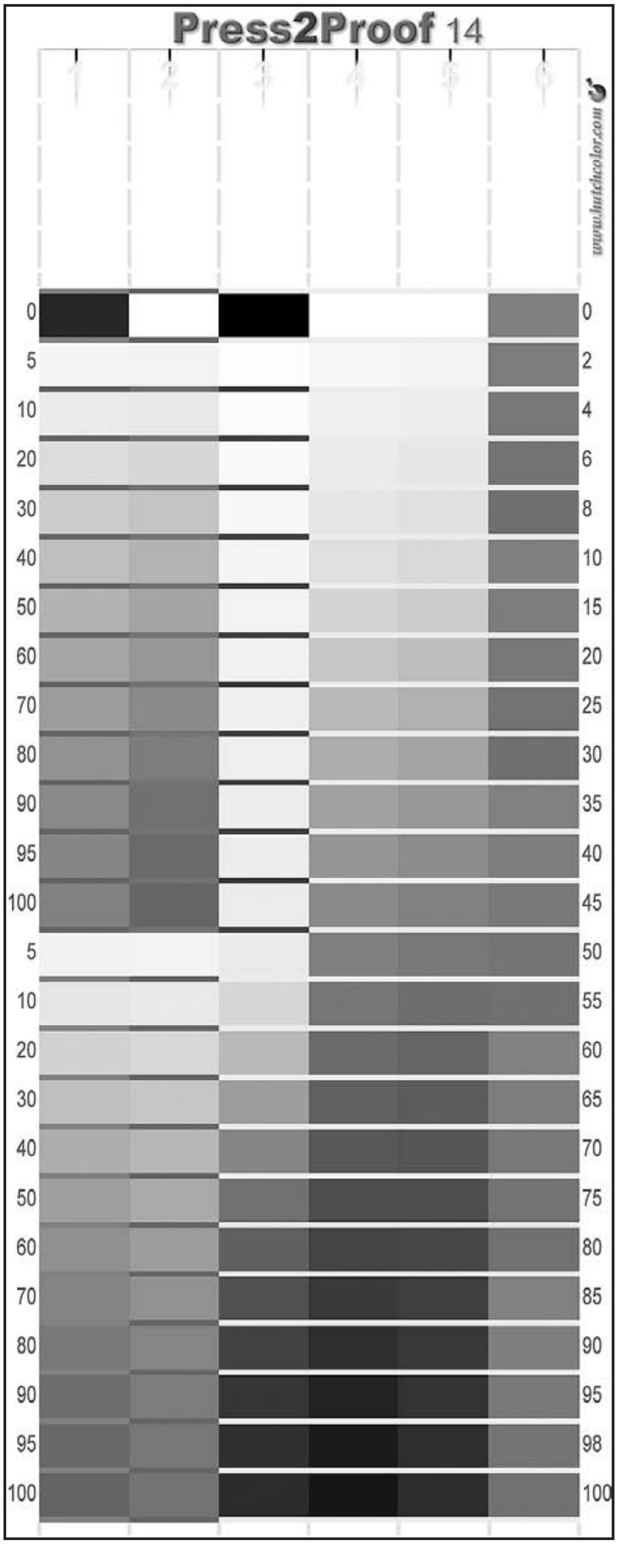


Figure 4. Press2Proof target

two-color press is used, black and cyan should be printed during the first pass (KC) followed by magenta and yellow on the second pass (MY). Other color sequences may be used. However, since altering the color sequence can impact the TVI of a given color (the first-down color is affected more by paper stretch than subsequent inks), the color sequence used when printing the test plates must be the same as that generally used in the instructional laboratory or particular production environment (Marin, 2005b). Changing color sequence can also affect two-color and three-color overprint trapping and affect registration-induced moiré.

Measuring the Printed TVI Values for Classic Process Control

Once the printed test sheets are completely dry, the 50% dot patches of cyan, magenta, yellow, and black are measured with a properly calibrated dot area meter or densitometer. Due to the pressure applied by the press to the dot, as well as optical shadows caused by the printed ink, the 50% dot patches will measure more than 50%. The difference between the measured percent and 50% is called tonal value increase (TVI) or dot gain. If, for example, the cyan 50% dot measures 67%, the TVI is 17%.

The target TVI values for a given paper and process are indicated on the appropriate row of the Print Characterization Chart (summarized in Table 1, but available in greater detail in SNAP, GRACoL, SWOP, and FIRST). To bring the printing process under control, it is necessary that adjustments be made to the image- or platesetter so that a 50% dot on the printed sheet measures *what the Print Characterization Chart* specifies. Marin (2005a) suggests a table, such as Table 2, be prepared to show how the measured dots sizes vary from the appropriate target.

K 67	*72 (50 + 22 TVI)*	*5*
C 65	*70 (50 + 20 TVI)*	*5*
M 64	*70 (50 + 20 TVI)*	*6*
Y 61	*68 (50 + 18 TVI)*	*7*

Table 2: Calculating weight to be added (subtracted)

Measuring the PDC for Colorimetric Process Control

Once the printed test sheets are completely dry, the CMY gray and black-only scales of the Press2Proof (P2P) target (available free at **www.hutchcolor.com**, and included in the SWOP and GRACoL test forms) or an equivalent target should be measured with a properly calibrated densitometer or spectrophotometer (see Figure 5). If a densitometer is used, the visual (neutral density) channel must be selected when measurements are made. If possible, the densitometer should be zeroed on white paper so that paper reads zero density. If this is not possible, the paper density measurement should be subtracted from all other measurements to get *paper-removed* densities.

The target PDC for a given paper and process (which was not finalized when this paper was written) is indicated in the appropriate graph published on the GRACoL web site or in the *GRACoL 7* booklet. To bring the printing process under control, it is necessary that adjustments be made to the image- or platesetter so that the printed PDC closely matches the ideal PDC in the published standard graph. This can be accomplished by simple graphical analysis, with step-by-step instructions available on the GRACoL website and in the *GRACoL 7* booklet.

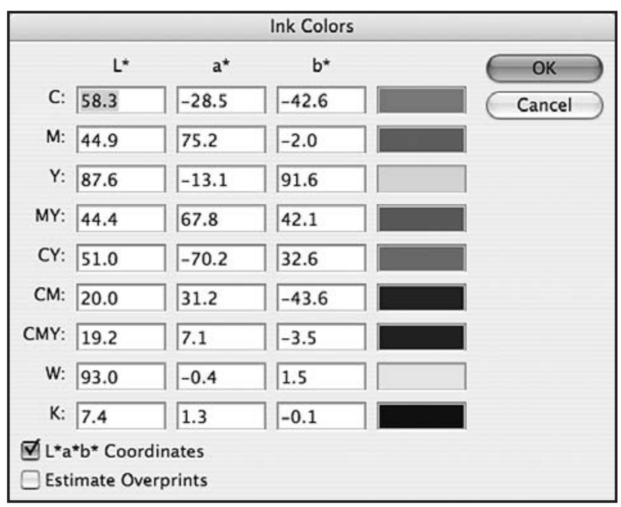
Building a Compensation Curve for Classic or Colorimetric Process Control

Once the printed TVI values (or PDCs) have been measured and the weight to be added (or subtracted) to bring the measurement into line with the appropriate line of the Print Characterization Chart (or desired PDC graphs) has been calculated, an *additional* tone curve (if based on linearized plates) or a *primary* tone curve (if based on *un-calibrated* plates) must be built for the image- or platesetter using its calibration software. A dialog box resembling the one in Figure 2 can be used to enter the weight to be added to the 50% dot. For example, if, as in Table 2, 5% must be added to the cyan 50% dot to bring it into line with the GRACoL 6 TVI guideline, 55% would be entered in the 50% field. "Most calibration software allows you to simply apply a value for the 50% dot and the rest of the curve will fall into place" (Marin, 2005). However, some RIPs and calibration software require the technician to enter a pre-set number of steps, for example in 10% increments. Other RIPS require the operator to enter not the *desired* value, but the *measured* value of each point. It is up to the individual operator to know the correct procedure for his or her particular software. This process must be repeated for each color when classic process control is used. But, in the case of colorimetric process control, a single curve will normally be shared for CMY with a separate curve for black ink.

Image New CMYK Test Plates Utilizing the Compensation Curve

The type of image to be printed with the curved plates depends upon the method to be used to generate color separation settings. One older—and discouraged—technique involves measuring solid-color CMYK samples as well as their overprints with a hand-held spectrophotometer or colorimeter (Figure 5) and inputting the results

Figure 5. Hand-held spectrophotometer



Ink Colors

	L*	a*	b*
C:	58.3	–28.5	–42.6
M:	44.9	75.2	–2.0
Y:	87.6	–13.1	91.6
MY:	44.4	67.8	42.1
CY:	51.0	–70.2	32.6
CM:	20.0	31.2	–43.6
CMY:	19.2	7.1	–3.5
W:	93.0	–0.4	1.5
K:	7.4	1.3	–0.1

OK
Cancel
☑ L*a*b* Coordinates
☐ Estimate Overprints

Figure 6. *Photoshop's* Ink Colors dialog box

into *Photoshop's* Ink Colors dialog box (Figure 6). In such a case, any test image, such as the one shown in Figure 3, can be used so long as it includes patches of solid C, M, Y, and K as well as overprints of M+Y, C+Y, C+M, and C+M+Y. The white paper must also be measured.

The second, and more accurate, technique for generating color separation settings is to use an ICC-profile-generating program, such as X-Rite's *Monaco Profiler*, or GretagMacbeth's *ProfileMaker*, along with accompanying hardware. If this method is used, the ICC-profile-generating software will output a specialized test form that must be printed and subsequently measured with a scanning manual or automated spectrophotometer (Figure 7).

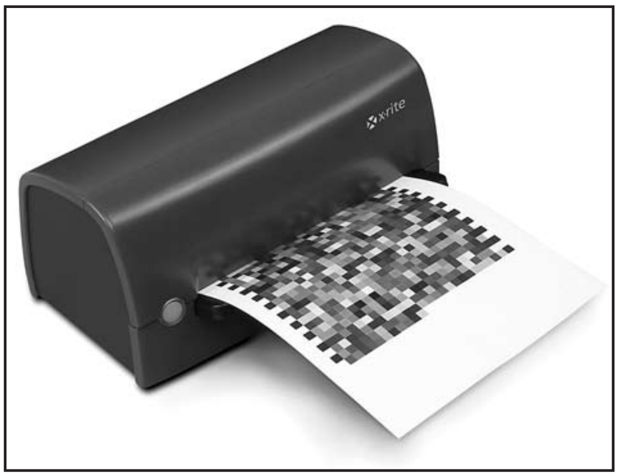


Figure 7. A scanning spectrophotometer analyzing a specialized test form

If an ICC profile is to be created, it is important to set the black generation, maximum black ink dot percentage, and TAC values before the software generates the test form. Figure 8 illustrates a dialog box in *Monaco Profiler* that is used to make these settings.

Black Generation: There are two methods of black generation, *Undercolor Removal (UCR*) and *Gray Component Replacement (GCR)*. Each of these techniques replaces some C, M, or Y ink with black. However, the difference between UCR and GCR is often misunderstood. The original purpose of UCR was to reduce C, M, and Y in deep black areas to achieve the required TAC. UCR is typically controlled by the TAC (also known as *Total Ink Limit*) value. The shadow detail removed by UCR is restored by the black plate, which is generated from the lightest value of C, M, or Y. UCR is further controlled by a *start point* that controls where the black begins to print on the tone curve, a *strength* or *weight* control that controls the black's basic curve shape (and thus the amount of CMY replaced by black on a gray scale), and a *maximum black* control that limits the highest percentage the black plate can achieve in deep black image areas. Because UCR replaces equal amounts of CMY, it leads to color desaturation if applied to tones other than the darkest and most neutral. For example, removing 20% CMY equally from a dark saturated red limits the maximum magenta and yellow ink values to 80%. This limits the saturation of that red.

GCR affects neither TAC nor the black curve shape in neutral grays. Also, unlike UCR, it does not desaturate colors because it replaces the *unwanted*—or *contaminating*—C, M, or Y ink(s) in dark colored areas while preserving most of the *wanted* inks. For example, if a red area is composed of C=40, M=100, Y=90, the 40% cyan does not add to the strength or saturation of the red color. Instead, it grays-out, or *desaturates*, the red. By replacing the 40% cyan with (nominally 40%) black ink, but leaving the M=100 and Y=90 values largely untouched, GCR produces a saturated red of the same or greater equivalent darkness as compared to a corresponding red that has not been altered by GCR. By reducing the unwanted ink(s) more than the wanted inks, GCR actually extends the maximum possible color gamut of a CMY ink set in dark colors. This is explained by the fact that black ink is approximately equivalent to equal parts of cyan, magenta, and yellow. So, adding 40% black to 100% M and 90% Y is approximately the same as printing C=40, M=140, Y=130. This combination yields 40% more redness than would be possible with CMY inks alone. The same process occurs in all less-than-pure colors within an image.

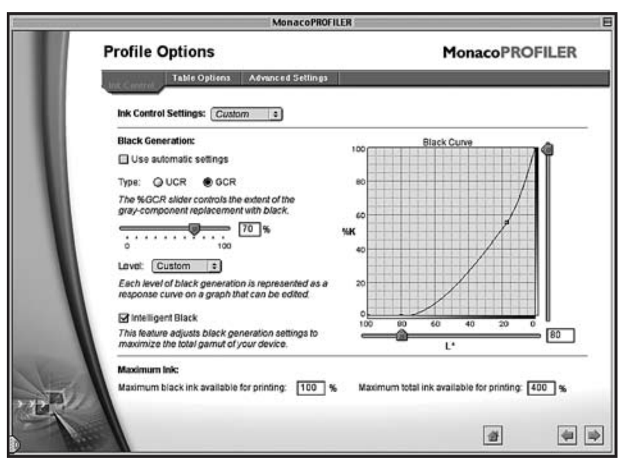


Figure 8. ***Monaco Profiler's*** **Profile Options dialog box**

SWOP (2005) strongly recommends the use of UCR or GCR: "...Undercolor Removal (UCR) or moderate amounts of Gray Component Replacement (GCR) is essential in making color separations." In particular, SWOP (2005) recommends that a range of 30–60% GCR be used. *GRACoL 7* encourages the use of GCR. Although FIRST defines UCR and GCR, it provides no recommendations on their use. SNAP is silent on the issue.

The amount of the effect that GCR causes is dependent upon the percent chosen: "A 50% GCR setting removes 50% of the gray component normally produced by the chromatic color and compensates by adding an equivalent amount of black" (SWOP, 2005). In *Photoshop*, the Black Generation popup menu in the Custom CMYK dialog box (see Figure 9) provides five GCR presets: None, Light, Medium, Heavy, and Maximum. *None* produces a CMY separation (no black) while *Maximum* provides the highest GCR effect. The *Medium* setting approximates the 50% GCR recommended by SWOP.

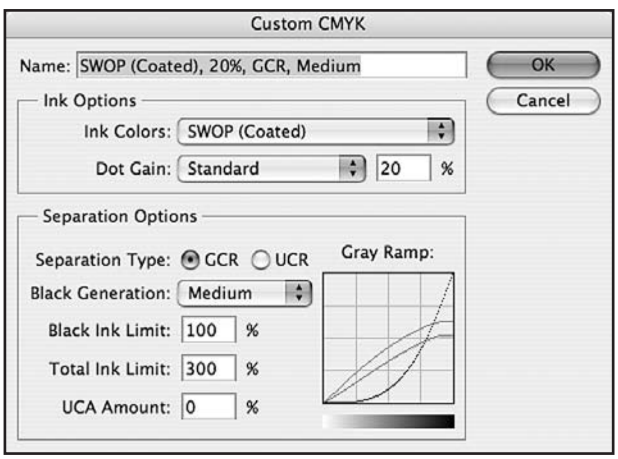


Figure 9. ***Photoshop's*** **Custom CMYK dialog box**

GCR (or UCR) is specified when creating ICC Profiles. For example, the *Monaco Profiler* Profile Options dialog box (Figure 8) allows the operator to select UCR or GCR and, if GCR is chosen, specify the extent of the GCR effect using a 0–100% slider. This percentage range can be deceiving as GCR algorithms work differently depending upon the profiling software employed. Therefore, it is more important to limit the black weight (strength of the black curve) than the actual GCR percentage value. Each profiling software package handles black weight differently. For example, *Monaco Profiler* (Figure 8) provides curve handles, similar to those in *Photoshop's* Curves dialog box, for adjusting black start point and black curve shape. The technician can also set the shadow limit with *Monaco Profiler's* Maximum Black Ink Available for Printing field.

Both UCR and GCR save expensive process inks, decrease the total amount of ink necessary to print a given job, decrease ink drying time, and make it easier to control color balance on the press. However, only GCR actually enhances the color gamut by replacing the desaturating component with black. Therefore, if a choice is offered between UCR and GCR, GCR is generally the better tool to use.

Since GCR can be applied safely without fear of reducing saturation, it can be extended throughout the whole neutral scale—even into highlight areas—and thus maintain neutral grays regardless of press variations. However, maximum GCR should only be used in consultation with the printer because it requires much closer control of the black plate than usual.

Excessive amounts of GCR can make it impossible for the press operator to match the color content of a non-color-managed proof. However, if the proof is produced using an ICC profile of the actual press, high GCR can be accurately matched between press and proof.

Tone Value Increase: TVI, or dot gain, most greatly affects midtone dots. However, shadow dots are also enlarged by the pressure applied to the dot by the press as well as by the shadow the dot casts (mechanical and optical dot gain, respectively). When shadow dots gain, they close up or print completely black. Therefore, any image that is composed of dots greater than a given size will contain no detail. The given size depends on the characteristics of ink, substrate, and press. A fingerprint test, such as the one described in Waite (1997) or Waite (2003), is used to determine the largest consistently printable halftone dot for a given ink, substrate, and press. This dot size is entered into the Maximum Black Ink field in profiling software (see Figure 8) or the Black Ink Limit field in *Photoshop* (see Figure 9). In the absence of such a test, Willmore (2002) recommends the Black Ink Limits shown in Table 3 (all four printing industry guidelines are silent on this issue).

Press and Paper Stock	*Black Ink Limit*
Sheeted Coated Stock	*94%*
Sheetfed Uncoated Stock	*90%*
Web Press Coated Stock	*90%*
Web Press Uncoated Stock	*86%*
Web Press Newsprint	*80%*

Table 3: Suggested Black Ink Limits

Opinions differ on black ink limits. For example, GRACoL chairman Don Hutcheson suggests that setting the black ink limit higher (e.g. 98% for commercial and SWOP separations and 85-90% for newspapers) produces richer blacks and reduces drying time without any negative side-effects. His argument is that black is the most effective ink in forming shadow detail and should be used as generously as possible.

Area Coverage: *Area Coverage* is the sum of all the ink percentages used to create a given color. For example, if a color were defined as C=5, M=90, Y=75, K=5, its area coverage would be 175 (5+90+75+5). *Total Area Coverage* (TAC) is the maximum sum of cyan, magenta, yellow, and black that can be used at any point in a given color separation. If, for example, the TAC for a given substrate, ink, and paper was 290% and a particular area of the image was composed of C=80, M=90, Y=80, K=45, the TAC would be exceeded (80+90+80+45=295). Surpassing TAC on a multicolor press generally results in drying problems that can spoil the finished job. TAC guidelines for SNAP, GRACoL, and SWOP are shown in Table 1. FIRST recommends the following TACs.

	Corrugated	*Paper*	*Film*
Wide Web	*270–300%*	*290–320%*	*300–340%*
Narrow Web	*N/A*	*290–320%*	*300–340%*

Table 4: Total area coverage values recommended by FIRST

No matter which color separation technique is employed, it is important that both the linearization *and* compensation curves be applied to the film or plate during imaging. It is also important that halftone dot targets be included on the test plates so that correct TVI and ink density can be verified during the press run. In addition, if Colorimetric Process Control will be utilized, a C=50, M=40, Y=40 gray patch must also be included alongside a K=50 patch. These two patches must repeat at ink-key intervals. Plates should be imaged at the appropriate LPI as specified by the relevant line of the Print Characterization Chart (Table 1) or in the pertinent printing industry guideline.

Printing Curved CMYK Test Sheets

Once an appropriate set of curved CMYK test plates have been imaged, those plates need to be printed on the targeted press using the same paper utilized when the linearized (classic process control) or un-curved (colorimetric process control) test plates were printed. The press must be controlled so that the sheets match both the SID and TVI (classic process control) or HR and GB (colorimetric process control) targets of the appropriate printing industry guideline. The ink color sequence must be the same as that employed when the test plates were printed.

Manually or Automatically Analyzing the Colors on the Curved Test Sheets

If an ICC profile is to be generated based on the printed test sheets, a scanning spectrophotometer (see Figure 7) is used to measure the printed patches. Profile-generating software compares the printed colors to known samples and automatically generates a profile that describes the color reproduction characteristics of the given press, ink set, and substrate when the TVI and SID (classic process control) or HR and GB (colorimetric process control) are controlled in accordance with the appropriate printing industry guideline.

Printed ink patches on a test sheet, such as that shown in Figure 3, can also be used to generate a crude *pseudo-profile* in Photoshop's Ink Colors dialog box. However, this is *strongly discouraged* and should used only if the instructor does not have access to ICC profiling software and hardware.

If an instructor has no other recourse, the L*a*b values of solid layers of C, M, Y, and K, as well as trapped overprints of M+Y, C+Y, C+M, and C+M+Y are measured with a hand-held colorimeter or spectrophotometer (see Figure 5). The L*a*b values of the white paper are also measured. Those values are then input into corresponding fields in *Photoshop's* Ink Colors dialog box (see Figure 6).

To complete the pseudo-profile, several fields must be modified in the Custom CMYK dialog box. First, the Dot Gain Curves dialog box must be completed for each color (Figure 10) using the dot gain targets from the appropriate printing industry guideline plus 50% (thus, if the target is 20%, add 20% to 50% to arrive at 70%). Then, UCR or GCR must be chosen and, if GCR is to be employed, the black generation preset specified. Next, the appropriate printing industry guideline (see Table 1) should be used to set the Total Ink Limit (known as TAC in the guidelines) and the Black Ink Limit as discussed in *Image New CMYK Test Plates Utilizing the Compensation Curve*. Subsequently, the CMYK setting should be given an appropriate name in the Name field. To save the Custom CMYK settings as a *psuedo* ICC Profile, Save CMYK must be chosen from the CMYK Working Spaces popup menu in the Color Settings dialog box. The pseudo-profile should be given a distinctive name followed by .icc and then saved in the Profiles folder.

Providing Color Separation Settings to the Graphic Designer

If custom ICC profiles are generated, these profiles must be made available to graphic designers so that correct CMYK conversions can be made. If custom ICC profiles are not generated, then an appropriate generic profile (e.g. U.S. Web Coated (SWOP) v2) should be specified. One way to provide custom profiles to designers is by posting them on the printing company's website. Instructions should be included so that the designer knows *which* profile to download for a given job, where to put it on his or her hard drive, and *how* to select it in varying applications.

Calibrating the Digital Proofing System

A standard test form, such as shown in Figure 3, or the test patches required by a proprietary ICC profile-generating program must be printed on each digital proofing device that will be used in the workflow. If the ICC profile is to be generated automatically, a scanning spectrophotometer and relevant software are employed. Otherwise, the instructions for making a press pseudo-profile given in the *Manually* or *Automatically Analyzing the Colors on the Curved Test Sheets* section must be followed. However, instead of using TVI values shown in the appropriate printing industry guideline, the technician should measure the TVI for each process color using the appropriate 50% patch on the test sheet with a densitometer or dot meter. Then, those values

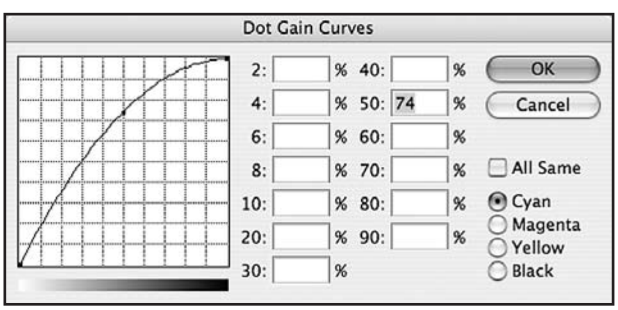


Figure 10. *Photoshop's* Dot Gain Curves dialog box

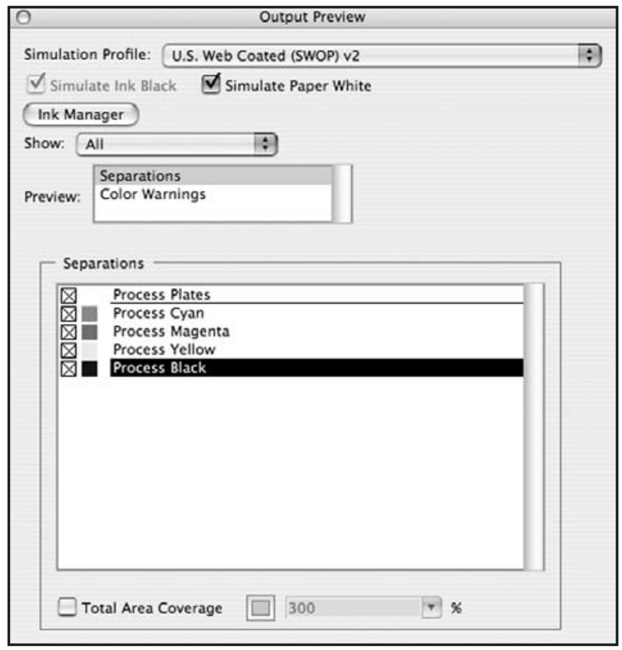


Figure 11. *Acrobat 7's* Output Preview dialog box

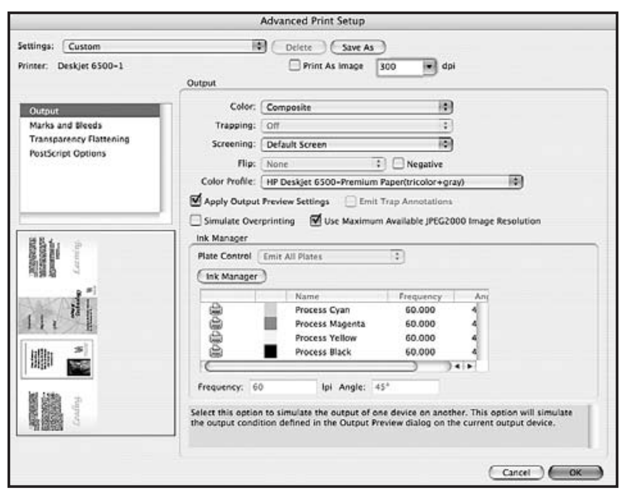


Figure 12. *Acrobat 7's* Advanced Print Setup dialog box

should be input into *Photoshop's* Dot Gain Curves dialog box (see Figure 10). The pseudo profile should be given a distinctive name followed by .icc and saved in the Profiles folder.

Since PDF/X-1a is the de-facto file format standard required or recommended by printing industry guidelines, calibrated color proofs must be made from these files. To print a calibrated proof from *Acrobat 7*, the Output Preview dialog box is used (Figure 11). The profile of the printing press that will do the final production must then be chosen from the Simulation Profile popup menu. Then, when printing the file, the Advanced button must be clicked so that the Advanced Print Setup dialog box will be displayed (Figure 12). When Output is selected from the scrolling list on the left, the ICC Profile of the proofing device can be chosen. If the Apply Output Preview Settings check box is selected, Acrobat will simulate the output device chosen in the Output Preview dialog box (Figure 11) using the currently chosen proofing device.

Other Guidelines of Importance to Print Students

SNAP, GRACoL, SWOP, and FIRST all provide numerous other guidelines of importance to graphic design and print production. Those particularly important to graphic designers are highlighted in a companion piece to this article entitled *What to Teach Graphic Design Students About Printing Industry Guidelines* (Waite, 2006). Another related paper, *Printing Industry Guidelines for Print Students Part One: Guideline Overview and File Format Considerations* (Waite, submitted), provides an overview of the guidelines, the PDF/X-1a file format they recommend or specify, and methods for shepherding PDF/X-1a files through a contemporary workflow. Since printing industry guidelines define the parameters for our industry, it is imperative that print instructors and professors procure and teach the guidelines relevant to the careers their students will follow.

Implications and Recommendations

This paper, along with its companion pieces, has highlighted a few of the guidelines recommended by printing industry groups. The guidelines underline an undeniable shift in the responsibilities of both graphic designers and print production personnel. Whereas printing company technicians used to *create* documents in a closed-loop environment, they are now expected to *process* documents created by graphic designers. In effect, printing companies have lost a good deal of control of the process because their employees are not those who create documents, scan images, or perform color separations. Instead, those operations are performed off-site.

To impose some order on the process, printing industry groups offer guidelines. Some of those guidelines focus on file formats and document transfer. In particular, the adoption of the PDF/X-1a format seems to be inexorable. The consequences of this PDF-centric workflow are widespread and force printers to implement software solutions to deal with PDF preflighting, trapping, editing, imposing, and RIPping. In addition, due to the CMYK-only nature of PDF/X-1a files, printers not only have to measure and profile their presses, but also *keep their processes under control*. These are challenges that must be met if printers are to stay competitive.

Students of print must be prepared to meet the challenges of the world of the printing and publishing industry, *as it exists now and in the foreseeable future*. Thus, instructional programs must change. Gone are the days when students could spend a majority of their time learning to create page layout files, create vector- or pixel-based images, and output to a laser or ink-jet printer. Yes, they need to know the basics of those processes so that their knowledge can provide added value to the company's sales force. However, the focus must be on successfully outputting PDF/X-1a files using a workflow that is process controlled.

Faculty are challenged to create curriculums that, while respecting the importance of page layout and image manipulation, emphasize a thorough understanding of the PDF/X-1a workflow along with practical experience in measuring and controlling the printing process. This may require a fundamental shift in the way courses are taught, the way laboratories are arranged, and the software employed. By way of example, the commonplace division of courses into prepress and press may hinder students from learning how to control the entire process. One cannot do prepress in a vacuum without knowing what the press is doing to the images. Another common practice that may need to be challenged is spending an inordinate amount of time in print technology classes doing tasks that are essentially within the realm of the contemporary graphic designer.

Textbook publishers and authors are challenged to write books that can be used by graphic arts teachers and instructors who wish to teach guideline-centric courses. For example, can an enterprising author come up with a way to teach students to measure and control the often low-end equipment that exists in most graphic arts classrooms? Or, can a textbook publisher commission a book that teaches PDFX/1a workflow from file acceptance through preflighting, editing, imposing, trapping, proofing, and RIPping?

Conclusion

National and international associations have standardized the variables inherent in various printing processes and have codified their recommendations into guidebooks such as SNAP (newspaper production), GRACoL (commercial printing), SWOP (publications printing), and FIRST (flexographic printing). If students of print are to be effectively prepared for careers as sales support personnel, managers, or technicians, they *must know* and be able to implement the contents of the appropriate guidebook. This article has reviewed a few of the more important implications of SNAP, GRACoL, SWOP, and FIRST that print students must know. To be truly effective, instructors, students, and practitioners should obtain each of the guidebooks and review them carefully.

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