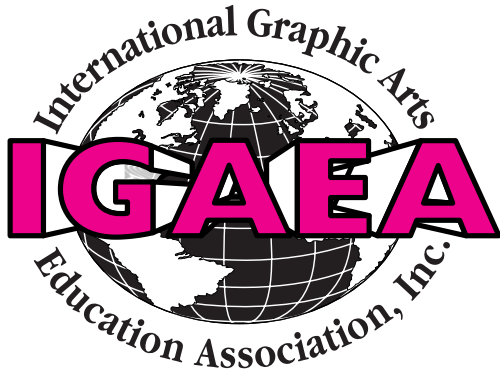




Visual Communications Journal

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About the Journal

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Editor's Note

The self-evident fact that printing and publishing is a digital world is no longer news. Rather, it is a fact of life in our business. In previous editions of the *Visual Communications Journal*, authors wrote about new digital technologies and their implications for business and education. This year, however, the “gee, isn’t that swell” attitude about digital technologies has been largely replaced with “how can we make this work?” This new attitude can be found in two common themes that permeate this year’s *Journal*. The first theme can be summarized as “how can we produce a quality product using today’s technologies?” while the second theme is “how can we use contemporary technologies to improve graphic arts education?”

Start by reading *Integrating the Seven Tools of Quality Into Printing*. In this paper, Mack and De Leon present the basic concepts of quality control from a printing and publishing perspective. Unlike other articles about quality, this paper provides examples related to printing and publishing that are relevant to graphic arts educators, students, and employers. Lord’s paper, *Assessment of Quality and Productivity Improvements in the Printing Industry Using the Baldrige Quality Criteria*, presents the results of a research project that examined how well printing firms have employed techniques similar to those outlined by Mack and De Leon. Perhaps most importantly, Rauch and Liedtke, in *A Review of Workplace Literacy Training in the Printing Industry*, reveal the futility of quality improvement programs if employees are not trained in the basic skills—reading, writing, and computing—that are necessary if improvements in print quality are to be realized.

Several other papers examine the use of today’s technology to increase print quality. Bradshaw and Schnellert, in *Printing on Plastics*, discuss the importance

of a thorough understanding of plastic substrates, and the inks that will be used to print on them, if a quality product is to be produced. Kellogg explains how to create and use a *Secondary Color Guide* to improve color communication—and thereby the level of perceived product quality—between printer and client. Hsieh, in *Factors Affecting Dot Gain on Sheet-Fed Offset Presses*, explains and attacks the ancient enemy of printers: dot gain. Waite’s paper, *Altering Grayscale Images to Compensate for Press Fingerprints*, continues Hsieh’s theme by explaining how Photoshop can be used to compensate for press factors, including dot gain.

Improving graphic arts education through technology is the theme of three papers. Lantz, in *Digital Video: A State of the Art Report*, provides the graphic arts educator with information necessary to build and offer courses or instructional units that will prepare students to create effective multi-media productions. Chung, in *Using Photoshop for Color Demonstration*, explains how graphic educators can use Photoshop to teach many concepts that would otherwise require a great deal of time and preparation to effectively present. Finally, Snyder provides graphic arts educators with a remarkable success story in *The Revitalization of a Traditional Graphic Communications: A Case Study*. Snyder provides, in detail, an effective process for transforming a traditional printing program into a state-of-the-art digital program.

Because of its breadth and depth, this year’s *Journal* is a remarkable document. All of us—IGAEA officers and members, students, and sustaining members from industry—are indebted to the fine work shared by each of the contributors. To each of them, we say “thank you!”

Printing on Plastics

by Larry L. Bradshaw and Gary L. Schnellert

Do you know of a manufactured product that doesn't contain some plastic? Plastics are found in coatings, sheets, and castings. They can be molded, vacuum formed, dipped, bent, machined, and even welded as they fit into a modern array of assembled parts and goods.

Nearly all manufactured products need to be printed, embossed, or made visually appealing, similar to most products made from any substrate. Printing on plastic fulfills aesthetic needs, provides information needed by consumers, and is often prepared by professional graphic designers (Elber, 1994). Prepress activities are carried out to print on plastic just as they are for any printing method or substrate. However, for the printer who is preparing to print on plastics, several unique problems to resolve are:

1. accurately identifying the properties of the plastic to be printed on;
2. acquiring the appropriate surface treatment if one is necessary;
3. selecting a compatible ink that will not only adhere to the substrate but also have the properties necessary to withstand the environment to which the printed item will be exposed; and
4. identifying the appropriate process to complete printing as a part of the manufacturing process.

Accomplishing these four steps is not an easy task. One must often locate several different sources and even communicate with more than one manufacturer before making any decisions. This can be time-consuming for novices who are attempting to gain knowledge of printing processes and plastics.

The purpose of this article is to provide readily available information on factors and procedures to consider when selecting inks and printing processes

to be used on a variety of plastics. Common defects are briefly addressed as well. This paper will also assist in identifying a simple process to use when seeking answers to difficult situations encountered when determining plastic substrates and appropriate printing processes.

Identification of Plastic Substrates

The first step, identifying the properties of the plastic substrate, is essential as there are many different varieties or combinations of substrates. Each substrate may be identified by its visual appearance, chemical composition, and physical characteristics (Crawford, 1987; Modern Plastics Magazine, 1995). It is advisable to perform some simple tests to ascertain the plastic substrate when planning to print on plastic. The following identification techniques are useful for determining the plastic substrate (Table 1).

Surface Treatment

Plastic surfaces must often be treated before decorating or imprinting. The treatment is for purposes of cleaning the substrate or to increase its wettability or adhesion so it will accept inks or paints. Several basic methods are described as follows (Elber, 1994; Modern Plastics Magazine, 1995):

1. Water washing utilizes alkaline cleaners to remove dirt and oils, and an aqueous emulsion of hydrocarbon solvents to remove mold release agents.
2. Solvent cleaning may be achieved by wiping, spraying, or immersion. However, one of the most effective methods of solvent cleaning is vapor degreasing. This process involves

Plastic	Visual Appearance	Substrate Test	Physical Characteristics	Typical Products
ABS acrylonitrile- butadiene-styrene	opaque, can be pigmented any color, dark shades of yellow, high gloss	flame - (inclusive)	tough and hard, vacuum formed, blow mold, extruded, chemical resistance, highest heat distortion point	safety helmets, automotive components, refrigerator parts, radio cases, toys
Acrylic	colored or colorless sheets; transparent or opaque sheets, rods; cast colorful	flame - yellow flame continues to burn when removed from heat source; when burning has an unpleasant monomer odor and a distinct crackling noise; has a fruity odor when an edge is being filed	good outdoor durability; made in sheets or rods with excellent clarity; scratches; resistant to water, salt solutions	Plexiglas®, outdoor signs, airplane canopies, tv and camera lenses, dentures, salad bowls
Amine	usually has fiber content visible when broken	flame - test results similar to phenolics	very hard, scratch resistant, unaffected by alcohol, oils or grease, can be stained by some food or drinks	electrical components, electrical insulation, dishes, counter tops
Cellulose acetate	high impact strength thermoplastic, usually in sheets	flame - yellow flame surrounded by blue and continues to burn when removed from heat source; initial odor is similar to vinegar	high impact strength thermoplastic, not chemically resistant, high surface tension	packaging, toys, book covers, laminations, lamp shades, toothbrush handles
Phenolics	hard, opaque, usually has fiber content (observed when broken), usually brown color	flame - will not burn but turns into carbon-like substance; pungent odor that is unique to phenolics	high heat tolerance, rigid, solvent, resistant	electronics, electrical insulation, appliances
Polycarbonate	either transparent, translucent or opaque, flexible yet holds its shape, waxy feel	bubbles and chars when burning, continues to burn after removal from flame, with sputtery orange and black smoke; nearly impossible to break with a hammer	moisture resistance, heat resistant (can be sterilized) tolerant to cold temperatures, molds, cast extruded	food containers, protective headgear, air conditioning housings, decorative sheeting
Polyester	rigid or flexible, transparent or translucent	flame - yellow flame that burns after removal from flame; burns rapidly and forms droplets; sweet odor; oily feel	tough, rub resistant flexible, high electrical resistance; not easily torn; resistant against organic solvents; liquid, dry powder and cast sheets, rods or tubes	pressure sensitive decals, encapsulate electronic parts, Mylar®
Polyethylene (a polyolefin)	strong, lightweight, resistant to breakage, moldable, extruded, formed, easily colored	flame - has a blue core surrounded by yellow; turns transparent as it melts, forming tiny droplets; odor similar to candle wax	thermoplastic; waxy feel; strong, lightweight, resistant to breakage, moldable, extruded, formed, easily colored, must be pretreated before printing	polyethylene (treated) packaging, plastic bags, milk jugs, gasoline cans, soft drink cases, water tubing, squeeze bottles, toys
Polypropylene (a polyolefin)	lightest plastic ratio for weight/impact; high resistance to grease, oil, water and acids	flame - same burning characteristics as polyethylene but higher surface hardness	harder than polyethylene, great rigidity and surface hardness, scratch and abrasion resistant; must be pretreated before printing	housewares, medicine cups, luggage, toothpaste tubes, bottle caps, syringes, rope, shoe heels, handles and knobs
Polystyrene	hard, transparent often pigmented	flame - continues to burn after removal from flame; sputtery orange flame; fruity odor like marigolds	hard, rigid, heat and dimensional stability, ease of fabrication; resistant to water, alkalines, alcohols and mineral oils but not to most solvents; tasteless and odorless	cassette/CD cases, plastic cutlery, photo lenses, scale models, insulated cups
Vinyl	wide range of flexibility	place heated copper wire on surface of a plastic film then immediately return wire to the flame; look for a yellow and green tinged flame that stops burning when taken out of flame; produces black soot and gives off an acidic odor while in flame	rigid or flexible; hard vinyl is resistant against water, acids, alkalines, alcohols, petroleum and oils; (soft vinyl is less resistant to chemicals)	wire insulation, PVC pipes, floor covering, shower curtains, rainwear, book covers, decals, signs

References: Baird, R. J. (1971); Cope, D., & Conaway (1966); Cope, D., & Dickey, F. (1973); Cope, D. & Schaaude, L.E. (1982); Crawford, R.S. (1987); *Modern Plastics Magazine*. (1995); Page, M. (1977); Screen Printing Association International (SPAI), (1984); Phillips Chemical Company (1983); Screen Printing Association International (SPAI) (1984); Richardson, (1989).

Table 1. Plastic Identification Guide for Selected Substrates

bathing the part in solvent vapors. The solvent condenses on the plastic and runs off, taking the contaminants with it. With this method the solvent that reaches the part is always clean.

3. Mechanical abrasion may involve tumbling or sandblasting.
4. Chemical etching with chromic or sulfuric acid chemically changes and/or roughens the surface. Fluorocarbons do not etch as other plastics but may be treated with sodium naphthalene.
5. Flaming oxidizes the plastic surface. The flame usually contacts the surface for less than a second.
6. Corona discharge involves exposing the plastic film surface to many small electrical sparks. This process oxidizes the plastic surface by forming polar groups; the roughened surface is more receptive to ink.
7. Plasma treatment is a batch process in an evacuated chamber where the surface reacts with an ionized gas, usually oxygen.

Compatibility Between Ink and Plastic

Several issues need to be taken into account when determining the ink of choice once the plastic substrate is determined:

1. Will the ink chemistry dissolve the plastic?
2. Will the ink adhere to the plastic?
3. Will the ink hold up to the environment into which the plastic will be placed?
4. Will the ink be safe for the intended use (e.g., for children or for food packaging)?
5. Can printing and clean up be accomplished with environmentally safe solvents?

The formulation of inks for printing on each plastic varies depending on whether the substrate is to be subjected to environments such as dishwashers, alcohol, or ultraviolet light, rather than being printed for decorative purposes. Sometimes the printing is intended for a short life, such as bread wrappers or packaging for candy or toilet tissue. Other applications require permanence such as in medical

syringes and devices for volumetric or linear measure. Who has not been annoyed by letters wearing off keyboard keys?

When getting ready to print, a common procedure used for small batch production is simply to refer to an ink substrate compatibility chart. However, for mass production, it is more feasible to ask the ink manufacturer to tailor the ink to suit the needs of the application. The manufacturer may also suggest additional pretreatment measures to insure adhesion between the ink and the item being printed.

Ink manufacturers and customers are both interested in product performance. They have their product's reputation at stake and are willing to share their research methods with the printers who are their customers. Ink manufacturers may also advise printers of possible testing procedures for a printed product. When the printing job passes the adhesion and environment testing procedures, the printer will have confidence that the job will stand up to design specifications. On the other hand, if the printing job fails, ink researchers must be involved immediately because they are the best resource for identifying a solution to the problem.

Inks can be compared to paint. In reality, inks are adhesives formulated for a particular substrate and usually contain pigments. Inks for plastics may be alcohol-based dyes or water-based pigments as used in the flexographic printing process. Most are solvent based and require a solvent similar to lacquer thinner for clean-up. There are inks made from plastic monomers which do not contain solvents that evaporate into the environment, but rather cross-link when placed in an environment of strong ultraviolet light. These inks have some environmental saving qualities but should never be used without first consulting the ink manufacturer to determine the required safety precautions and procedures necessary to prevent injury to persons using them in the printing area of manufacturing.

Some inks may be two part inks which have some form of epoxy resin as the ink vehicle. Before their use they usually will need to be mixed, then let set for approximately a 45-minute induction time before adding any viscosity control thinners for the printing

process. These types of inks will also have a pot life; that is, the time after the induction time that printing will still remain effective with the mixture. The induction time and pot life information should be obtained from the ink manufacturer.

Additives to ink may improve one quality for the ink but, at the same time, reduce or eliminate another desirable quality. Some of the features that can change are viscosity, (different pigments cause viscosity to change from rheopathic to thixotropic), adhesion, weatherability, chalking, abrasion resistance, chemical resistance, and gloss (Daley, 1982; NazDar/Kc, 1993).

Components of Inks

Single-component inks are formulated from epoxy resins blended with heat curing resins. Commonly used heat-curing resins are urea-formaldehyde and melamine formaldehyde, or phenol-formaldehyde. The amino blends are selected when color retention is important. Phenol blends are chosen when abrasion resistance is important.

Two-component inks are the most commonly used today. They require a catalyst, and may be air dried or baked. Polyamines and polyamides are two common catalysts. The amines have good color retention and excellent resistance to oils, solvents, chemicals, humidity, and salty environments, but have higher toxicity than the amides. Amines usually have a shorter pot life, shorter curing times, and lower baking temperatures. On the other hand, the amides are better for chemical resistance, lower toxicity, greater adhesion, flexibility, and impact resistance. Polysulfide catalysts are used less but provide chemical resistance and flexibility in addition to the properties offered by the amides.

It is important to note three basic things about inks (Eldred, 1993). First, selecting ink with a fast cure may result in a yellowing effect. Second, after opening, catalysts may absorb moisture and become ineffective in approximately one week. Finally, epoxy resin inks are not suitable for outdoor use as they tend to chalk within 90–120 days.

Flexography

Flexography is the term used to indicate a process of reproducing graphics on products. Actually, as defined by the Foundation of Flexographic Technical Association (1991), “Flexography is a method of direct rotary printing that uses resilient relief image plates of rubber or photopolymer material” (p. 4). As shown in Figure 1, a typical print station is comprised of seven components: “(A) Ink fountain with fluid ink; (B) Rubber ink fountain roll; (C) Reverse-angle doctor blade (if used in the system). (D) Ink-metering (anilox) roll; (E) Printing plate cylinder; (F) Substrate traveling through press; (G) Impression cylinder.” (p. 5).

The quality of the graphics are determined by need. Some flexographic materials are printed to last a short duration, such as on disposable containers, bread wrappers, cartons, etc. On others, especially where instructions are needed for product use, the flexography must be durable for the lifetime of the product. Other factors such as attractiveness and type of use strongly influence the flexographic ink and plastic selected for the product. Following is a summary of useful information (Foundation of Flexographic Technical Association, 1993) about several inks and plastic substrates commonly employed in flexography.

Common Inks

1. Polyester is usually printed with alcohol-

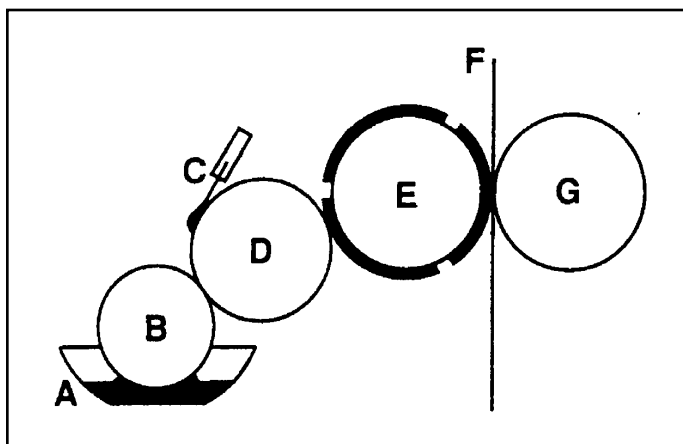


Figure 1. Typical print station. Source: Foundation of Flexographic Technical Association, Inc. (1991).

reduced polyamide resins. These inks have low odor, deep freeze flexibility, and water resistance. If surface hardness needs to be improved, about 10% of the resin is replaced with nitrocellulose.

2. Polypropylene inks are formulated as for polyester unless heat and/or grease resistance is required. Ink with these qualities will be modified with polyamide resins, rosin derivatives, and plasticizers. Polypropylene does not accept or retain surface treatments as well as polyethylene.
3. Saran and polyester films will use polyamide inks as described for polyesters. Saran is applied as a coating, uncoated polyester may be treated with a primer of acrylic resin.

Other Types of Inks

1. Inks for foil and glassine are formulated after review of all the converting processes they will go through.
2. Dye-based ink for paper, foil, and glassine often have a mordant agent (tannic acid) added to improve alcohol solubility and reduce water solubility.
3. Pigmented inks are used where light-fastness, bleed resistance, or heat resistance is required. Dyestuff dissolves in ink solvents, and pigments are insoluble.
4. Water base inks may use polyvinyl alcohol, hydroxy ethyl cellulose, and polyvinyl pyrrolidone as vehicles. Water base inks may also use alkaline solutions of acidic resins (water soluble salts similar to soap). Water base ink may also use fine particle resins (colloidal suspensions in water). Many water based inks have a combination of vehicle types.

Solvents

Each substrate is unique and requires a different ink mixture and solvent (see Table 2). Most solvents are not chemically pure but contain small amounts

of impurities which affect their properties. Therefore, the values given in Table 2 are approximations for the three most common commercial grade solvent types (Alliance of American Insurers, 1980a, 1980b; Lutz, 1991). The mixture of ink and solvent greatly influence printing quality and weatherability.

Printing Processes

Information and decorative design provided for polymer substrates is continually expanding as new polymers, dyes, inks, pigments and processes are developed. The information given in Table 3 is a preview of the processes available in decorating plastics (Elber, 1994; Eldred, 1993; Kalpakjian, 1993).

Post-Printing Defects

Coating defects often have picturesque names that become important when one is attempting to describe a defect to a coating supplier. At the point when audio is the only method of communication, using the right term is vitally important. Listed in Table 4 are some of the most common terms and a brief description of reactions.

The Future of Printing on Plastics

Plastics have become an integral part of the manufacturing industry. Today, most products contain varying degrees of plastic. Hayter (1982) studied seven major industrial impact categories on one group of plastic and six groups of non-plastic manufactured containers such as glass, coated steel, aluminum, paper products, etc. The plastics showed superior coefficients, confirming that they are here for the long haul. The categories under study were: (1) energy usage; (2) water consumption; (3) atmospheric emissions; (4) post-consumer wastes; (5) solid waste generated at manufacturing; (6) raw materials; and (7) water-borne wastes.

Plastics are petrochemical organic materials that are easily manufactured and are cost-effective, especially for unique applications and small components.

Considering the seven impact categories listed in Hayter's (1982) study, the energy and water consumption for manufacturing the plastic containers was less than for all of the conventional materials studied. The majority of the conventional materials used in the manufacture of containers had higher atmospheric emissions than plastics. Post-consumer and solid manufacturing waste of the conventional materials was also higher than for plastics. The remaining two categories, raw materials and water-borne wastes, used in the manufacture of containers had differing results based on the the manufacturing methods used.

Several other factors were considered in the study, of which weight was one. The weight of plastic is less than glass, therefore it takes less energy to move plastic and its contained product. Another factor examined was breakage. The plastic protected the contents better. If breakage occurs for glass, one loses both the container and contents, doubly impacting the environment. A third factor looked at was recyclability. Today nearly all plastic scrap can be recycled. Plastics come from oil, coal, or natural gas,

and plastic products retain nearly all the original energy value that they had as raw materials. Plastics do reduce the amount of oil consumed from driving autos and heating homes, but they are in a form which, if needed, could be reused as fuel.

Today, plastics have become a pervasive part of our way of life. Carpets, wash-and-wear shirts, knit slacks, stretch socks, ballpoint pens, videos, and many other products, would not be available or would cost much more if it were not for plastic. The economic gain factor for the plastics industry is that for every dollar spent, seven are returned to the local economy, which is a greater figure than for any other manufacturing industry.

In the mid 1950s, plastics were considered as substitutes for the real thing, whereas in the 1990s, plastics are the real thing. For the future, plastics and printing on them will take on increasingly important roles. New products, new environmental demands, and fewer resources all make plastics very attractive. One of the big challenges for the future is to determine effective ways to identify co-polymers and to pinpoint co-plastic processing methods to

text continued on page 9

Solvent	Flexography	Screen	Boiling Range		Kauri Butanol (KB) Value	Flash Point	
			°F	°C		°F	°C
Aliphatic hydrocarbons ¹							
Heptane	X		201-207	94-97	29	20	-6
Hexane	X		208	98	-4	25	
Lactol spirits	X	X	205-240	96-115	36	30	-1
VM & P naphtha	X	X	215-295	102-146	38	57	14
Napthol mineral spirits		X	295-325	146-163	34	95	35
High flash mineral spirits		X	330-400	165-204	38	140	60
Standard 350		X	330-383	165-195	42	116	47
Stoddard solvent		X	340-385	171-196	30	105	41
Standard 410		X	360-410	182-210	44	140	60
Odorless mineral spirits		X	360-392	182-200	26	134	56
#460 mineral spirits		X	260-450	126-232	37	135	57
Aromatic hydrocarbons ²							
Benzene		X	174-176	79-80	110	5	-15
Holulene/toluol	X	X	230-231	110-110.5	105	41	5
Xylene/xylol	X	X	281-284	138-140	96	82	28
Socal 2		X	280-333	138-167	95	90	32
Socal 25		X	314-335	157-168	94	115	46
Super high flash naptha		X	324-355	162-179	90	116	46.6
Socal 355-L		X	314-335	157-182	69	112	44
Amsco F		X	360-395	182-201	77	140	60
Amsco G		X	360-4006	182-208	88	145	63

Table 2. Printing for selected solvents—continued on page 7

Solvent	Flexography	Screen	Boiling Range°F	Drying Rate*	Flash Point°F	Vinyl	Solvent for		
							Acrylic	Nitrocellulose	
Oxygenated solvents³									
Esters									
Amyl acetate		X	295-302	42	106	X	X	X	
2 ethyl hexyl acetate	X	X	390-402	1	190	X	—	X	
Isopropyl acetate	X		192		35	S	X	X	
n-propyl acetate	X		215		55	—	S	S	
Methyl cellosolve acetate		X	293-305	31	140	X	X	X	
Cellosolve acetate		X	312-328	21	136	X	X	X	
Butyl cellosolve acetate		X	374-378	3	190	S		X	
Carbitol acetate		X	422-435	1	230	X	X	X	
Butyl carbitol acetate		X	476-482	1	240	—	X	X	
Butyl acetate		X	258-262	100	100	X	X	X	
Butyl lactate		X	284-400	3	175	X	X	X	
Ethers									
Diethyl carbitol		X	370-374	4	180	X	X	X	
Dibutyl carbitol		X	489-492	1	245	—	—	X	
Methyl cellosolve		X	258-260	47	115	S	X	X	
Cellosolve solvent	X	X	275	32	130	—	X	X	
Butyl cellosolve		X	340-343	6	165	—	X	X	
Hexyl cellosolve		X	390-406	1	195	—	—	X	
Methyl carbitol		X	380-388	1	200	—	—	X	
Carbitol solvent		X	381-402	1	205	—	S	X	
Butyl carbitol		X	436-446	1	240	S	X	X	
Hexyl carbitol		X	494-948	1	285	—	S	X	
Glycols									
Ethylene glycol	X		387		232	—	—	S	
Propylene glycol	X		372	†	100	—	S	S	
Keytones									
Acetone	X	X	133-135	1,160	15	X	X	X	
Methyl ethyl ketone	X	X	175-178	572	35	X	X	X	
Methyl isobutyl ketone		X	241-242	165	75	X	X	X	
Cyclohexanone			266-335	23	130	X	X	X	
Methyl isoamyl ketone		X	292-294	45	110	X	X	X	
Ethyl butyl ketone		X	296-305	45	115	X	X	X	
Isobutyl keptyl ketone		X	420-424	1	195	—	X	X	
Isophorone		X	418-428	3	205	X	X	X	
Alcohols									
Diacetone alcohol		X	336-341	14	155	S	X	X	
Tetrahydrofurfuryl Alcohol		X	347-350	15	175	—	S	X	
Ethyl	X		173		52	S	—	S	
Methyl	X		147		53	S	—	S	
Isopropyl	X		180		74	S	—	S	
N-propyl	X		208			S	—	S	
Miscellaneous									
2 Nitropropane	X		248		75	S	X	X	
Ammonium Hydroxide (28%)	X	X				—	—	S	
Water	X	X	212			—	—	—	

¹straight-chain saturated hydrocarbons (for thinning enamels or poster inks; most suitable are those with a 330°F-400°F boiling point)

²benzene ring hydrocarbons (for enamels and poster inks with significantly less solvent; boiling points and KB values are much higher)

³polar hydrocarbons of hydroxyl or carbonyl groups often soluble in water (dissolve shellac, cellulose, esters, urea, melamine-formaldehyde resins and vinyl resins).

†Hygroscopic.

*Drying rate is expressed as the relative evaporation rate of a given solvent when compared to butyl acetate which is regarded as 100. Figures above 100 denote solvents that dry slower than butyl acetate.

Solubility of resins: X denotes complete solution; S indicates that solubility will vary from one resin grade to another; — denotes no solubility.

References: Alliance of American Insurers. (1980a, 1980b); Lutz, J. (1988); Phillips Chemical Company (1983); Screen Printing Association International (1984).

Table 2 continued

Process	Description
electroless plating	Used to apply a metallic coating to objects which are made of non-conductive materials. The plating occurs in a solution containing metal ions and a reducing agent. The plastic items are immersed in the bath until they are coated to a thickness deemed sufficient.
electroplating	Sometimes referred to electrolytic plating. This process uses electrical current to deposit metal from a metal salts solution onto conductive objects. Therefore, before plastic articles can be electroplated, they must be rendered conductive by electroless plating or by use of a carbon filter. An example are nickel-chrome alloy coatings which are commonly electroplated over electroless copper.
embossing	A process of applying textures to the surfaces of the plastic products. Textures can be applied to molded articles during the molding process. For films and webs the embossing may be applied through: casting a process of texturing by passing the material between rollers or subjected to a flat press; by dielectrically or ultrasonically heated dies; and by chemical means such as inks which expand when heated. Sheet stock may be painted before being embossing. When sheets are printed after embossing, the inks merely hit the high spots which is a desirable effect when imitating leather or textiles, if embossing and printing are to be done concurrently, the ink can be applied to the high points of the embossing roller which results in the low points of the embossed sheet receiving the ink. This process is referred to as inlay printing. Another method of filling the low spots of the embossed material is spanishing which floods the surface with ink and the excess is scraped off.
flexography	A printing method used to produce high-quality images on flexible packaging materials. A raised design is photo imaged onto a metal, rubber or synthetic plate. Likened to a rubber stamp, the high points on the plate is coated with ink and transferred to the surface to be printed.
flocking	The application of short textile fibers to an adhesive coated surface. This process produces a velvety flocked surface that is frequently used for toys, novelties and automotive interiors. The fibers utilized may be nylon, cotton, rayon or polyester. The procedure is the application of an adhesive coating on the plastic sheet or other object then the textile fiber flocking is applied by pneumatic and electrostatic means.
gravure	A printing method completed by means of an engraved (sunken image, intaglio) cylinder or flat cliché.
heat transfer labeling	Can produce detailed single or multicolor images through such processes by screen printing, flexography, gravure, or metalization on a paper carrier. A heated metal or silicone platen melts the wax or polymer release coating and transfers the image to the plastic. The transfer labeling processing is limited to flat or slightly curved surfaces.
hot stamping	Utilizes a heated metal or silicone die which presses the desired shape on a surface through a multi-layer web called a foil. The foil may have a multi-colored, marbled, wood grain or metallic appearance. Flat surfaces are usually stamped whereas cylindrical objects can be rolled across the die.
laser etching	Can be used to mark or etch the plastic. The movement of the laser beam is usually computer controlled, so the design can be changed for independent parts if necessary. Depending upon the variables of the material, the laser chosen, and the strength of the beam, the laser can produce an engraved mark, cut through the material, change the surface color, change the texture of the surface, or mark through a coating that reveals a contrasting layer below.
offset printing	A method where ink is transferred from a photo imaged plate to a rubberized blanket and then to the surface of a sheet. The process can be used to print images on sheets or webs.
pad printing	An ingenious method to decorate objects with compound curves. The process involved transferring ink from an image photo etched on a plate called a cliché to an accurate but highly deformable silicone pad. The pad is then rolled against the article to be printed. The pad can be wrapped around an object up to 180 degrees. The ink coverage is excellent with many specialty inks being available. As many as a four-color process is possible through pad printing.
screen printing	Can transfer high-quality images to flat or slight but uniform curved surfaces. To prepare the stencil-like material used for screen printing, a tightly stretched porous fabric or tightly meshed metal screen is coated with a photosensitive emulsion. A highly intense light is transmitted through a positive image of the design onto the emulsion. Exposed portions of the emulsion harden, whereas, the unexposed emulsion is washed away when the stencil is developed (washed out). A rubberized squeegee forces ink through the permeable parts of the stencil onto the plastic article to be decorate.
sputtering	A process where atoms of the coating material are dislodged by contact with an inert gas plasma such as argon. The gas is used rather than heating the material as in thermal spraying. Any metal can be sputtered onto other substrates.
thermal spraying	A process where a metal wire or powder is fed into a spray gun, melted by a gas flame and then atomized by compressed air, just like paint. Molten metal can be sprayed onto most plastics for functional or decorative purposes. The temperature of the substrate must withstand temperatures of 120-150 degrees Fahrenheit. Metals with a high melting point may be applied over a zinc or aluminum layer which would be applied first.
vacuum metalizing/ vapor deposition metalizing	This involves placing a piece of metal in a vacuum chamber and heating it to a point where it vaporizes under the vacuum. This is usually a relatively low temperature at which plastic does not melt. The plastic piece to be coated is kept cool enough for the metal vapor to condense on it.

References: Elber, G. (1994); Eldred, N.R. (1993); Kalpakjian, S. (1992); Phillips Chemical Company (1983); Screen Printing Association International (1984).

Table 3. Process for decorating plastics

Defect	Description
blushing	May occur when fast drying solvents cool the surface as they evaporate. When atmospheric humidity condenses on the cooled surface, it can create whitish patches on the coating.
chalking	The state referred to when pigment particles rub off as a chalky powder because of the loss of bonding after the pigment particles are applied.
craters	Appear as scattered depressions in a coating and are caused by disruptions of surface tension during drying. A crater can be larger than the impurity particle, dust, or bubble that caused it; because the coating pulls away from the site under surface tensions.
fish eyes	Craters produced in a coating by an excess of foam-inhibiting surfactant.
floating	May appear as horizontal separation of pigment into streaks or cells on a coated surface. It may be caused by flocculation of pigments.
flocculation	The clumping of pigments. The result may be an uneven distribution of color. However, such clumping can be a desirable result especially when attempting to prevent paint from sagging on a vertical surface. Surfactants may be added to paints to discourage flocculation.
flooding	Usually results when pigment settles out in the film of paint. This produces a mottled surface. Several factors may cause the flooding, improper milling of the pigment, excess solvent, or insufficient viscosity.
mooning	A term for the failure of the coating to adhere because of foaming. The result is a patchy appearance.
orange peel	The pebbled surface effect when the coating contains solvents that have different evaporation rates, or the problem could be caused by electrostatic charges on the surface.
pinholes	Small pits in the surface of the coating usually caused by air bubbles; the defects may also be the result of compounding, application, drying or curing.
wrinkling	Usually occurs when the surface coating dries before the inner layer. This allows the inner layer to dry and shrinks. The surface drying can be retarded by adding solvents with a high boiling point.

References: Elber, G. (1994); Phillips Chemical Company (1983); Screen Printing Association International, (1984).

Table 4. Common coating defects and a brief description of reactions

determine appropriate printing procedures.

This paper has sought to assist persons knowledgeable about plastics and plastics manufacturing to increase their understanding of the printing methods from which to choose. The paper was also intended to help printers of plastic goods increase their background on plastic manufacturing processes.

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Secondary Color Guide

A comparative guide for understanding the limitations of color space within the color printing process.

by Hans P. Kellogg

Scanning; Changing Times:

The current role of the scanner operator is changing. Positions previously held by trained technicians are currently assigned to photographers, desktop publishing operators, and office personnel. Skills once taught through apprenticeships and specialized instruction have been reduced to “read me” files and simplistic instruction manuals. Smaller and less expensive desktop scanners provide the novice operator a pleasing scan with little or no previous experience.

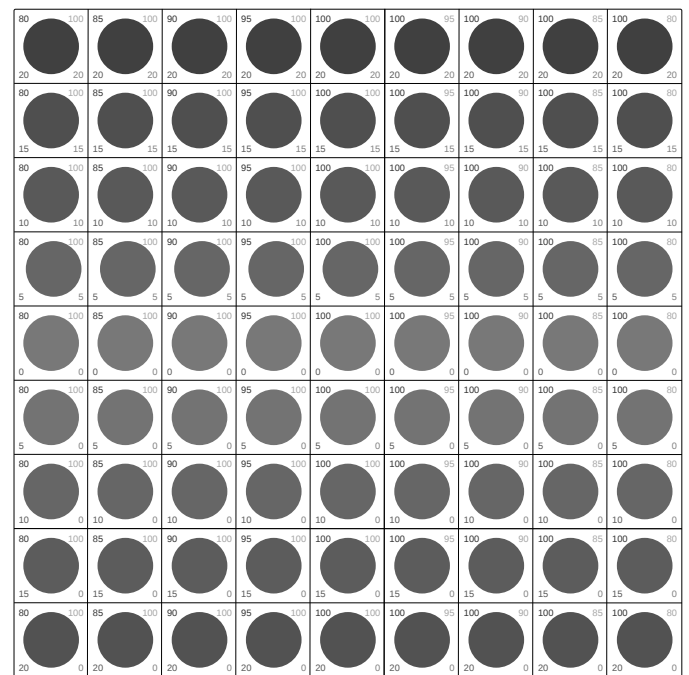
This new use of scanners presents some challenging questions. What will happen to the skills held by the traditional scanner operator? Are their skills still necessary? Do they merit consideration in light of today’s technology? Questions like these can easily arise while people are being trained on today’s scanners. The statement that “scanning is dead,” while echoed throughout the industry, becomes irrelevant if the skills of the seasoned scanner operators are still valuable. The real question to ask is: How do we transfer this knowledge to novice operators?

Graphic arts education needs to provide tools to clearly present the scanning process. Visual guides that compare and contrast the assessment of color evaluation are critical. The Secondary Color Guide (SCG) is such a tool. It is comprised of three different evaluation guides that depict the secondary colors of red, green and blue. The guide recognizes that the memory colors of red, green and blue are critical to the printing process. The SCG can be used to:

1. Visually display the extent of color gamut for secondary colors.
2. Judge the ability of a printing system to reproduce a given secondary color.
3. Guide the operator with color corrections of secondary colors.

The SCG provides an understanding of the limitations of the printing process as well as defining the

Secondary Color Guide



How to use the Secondary Color Guide

1. Select the appropriate guide to compare with a color in question.
2. View the guide and the original under the appropriate lighting conditions of 5000K.
3. Locate an accurate match by comparing the original to the guide.
4. If an accurate match is obtained, the color in question can be reproduced with this printing system. Using the appropriated dot values surrounding the color determine the dot percentages required to reproduce this chosen color.
5. If it is not possible to match an original to a select color patch, the color in question is outside the color gamut of this printing system. An alternate printing method will be required to obtain an accurate reproduction of this color.

amounts of yellow, magenta and cyan and black present within secondary colors.

Color Theory

A basic understanding of color theory is required to understand how the SCG can be used. The human eye uses three different color receptors, called cones, to “see” color. These cones are sensitive to either the red, green, or blue portion of the electromagnetic spectrum. Together the three different receptors produce the tristimulus sensation of color. Red, green, and blue are considered the additive primaries, a color theory based on light. Any combination of two additive colors will produce a primary color of the subtractive color process used in all printing processes. If you combine blue and green light, the color cyan is produced. Combinations of all three additive primaries produce white light.

The group of subtractive primaries (yellow, magenta, and cyan) are the basis of the inks used in color printing. The colors red, green, and blue are created when two subtractive primary colors overprint. A printed image of a red car appears red because magenta and yellow inks are printed together onto a substrate.

The pigments used in the cyan, magenta, and yellow inks are not pure and do not match the dyes within the photographic process. The color cyan should completely absorb red and reflect the blue and green portions of the light spectrum. In truth, the pigment in the cyan ink does not behave in this manner. The red light is not completely absorbed by the cyan, and the pigment even reflects portions of blue and green light.

Confusion for the Layman

A major problem associated with color printing is the reduced color gamut produced by the process. Color gamut is defined as the range of colors within a particular color process. The total number of colors within the four-color printing can’t match that of the photographic process. If the color of an original is not within the color gamut of the reproductive

process, an accurate match in the reproduction is not possible.

A major challenge in color printing is to evaluate the color produced. CIE (International Commission on Illumination) is an organization that has defined a scientific approach to this measurement process. They created a chromaticity (color) diagram to define the observation of color as it relates to human vision. CIE diagrams are frequently used to describe the difference between the various color processes. Limits of color gamut can be superimposed on top of a CIE diagram to show how each color media has decreasing color gamut.

However, CIE charts are not commonly understood by novice operators and are not designed to predict the proper amounts of yellow, magenta, cyan and black required to produce a particular color within an original. Without expensive equipment it is difficult to pre-judge whether a color can be reproduced using four-color printing.

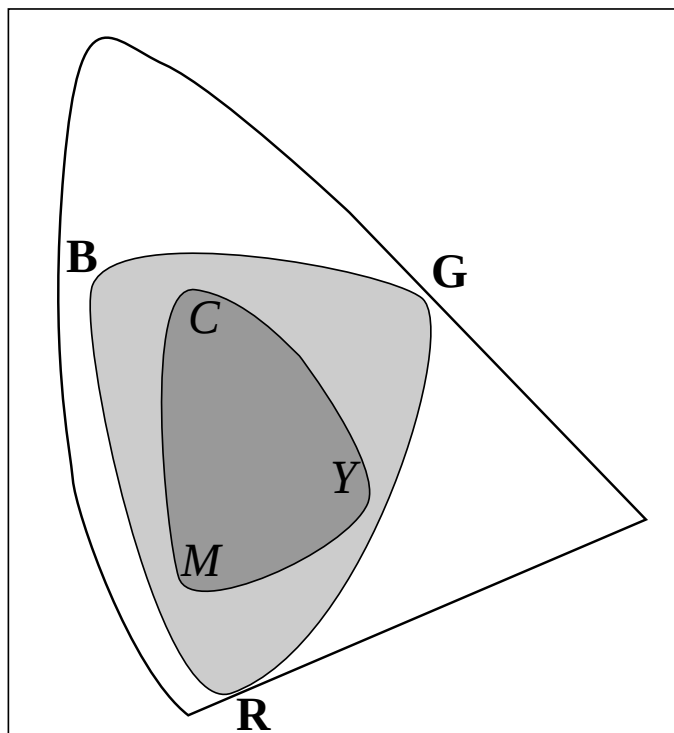


Diagram 1.
CIE chromaticity diagram comparing the limits of the four color printing process to the photographic process.

The Challenges of Working With Color

Experienced scanner operators can predict the ability of a printing process to reproduce a given color, but this remains a challenge for the novice operator. What is needed is a method to predict how much of each color of ink is required to produce a particular color.

For example, novice operators incorrectly assume that the colors of ink required to reproduce a red car are magenta and yellow. This isn't totally correct. While the combination of yellow and magenta will produce a red, it is a far cry from the color that would be expected when a red sports car is viewed on a transparency. Cyan and black are needed to give the red car its "depth." To deal with this challenge, an SCG can be used as a comparative guide to single out the proper amounts of yellow, magenta, cyan and black needed to match the image.

How to Create an SCG

The different colors of ink used to create the SCG will be defined by two dominate colors and a contaminating color. The two dominate colors define the hue. The contaminating color darkens the color. Black ink is also used to darken the color. Using the red SCG as an example, yellow and magenta are the dominate colors with cyan as the contaminating color.

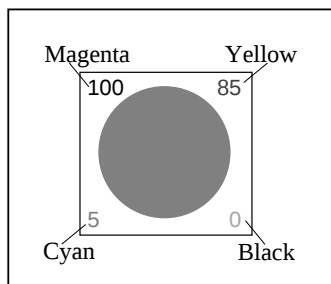


Diagram 2.

Surrounding each color patch is the "recipe" of dot percentages color coded with the yellow, magenta and cyan of ink. This marking makes the dot percentages easy to read and does not require a label for identification. For this example, the color patch depicted in Diagram 2 will be from the red SCG. The 100 in the upper left hand corner (printed in magenta ink) defines 100% coverage of magenta ink. The 85 in the upper right corner (printed with yellow ink) defines 85% coverage of yellow ink. The cyan 5 and black 0

(printed in cyan and black) finish the dot percentages for this particular color patch

To understand the pattern used to create the SCG it will be helpful to see the values of yellow, magenta, cyan and black separately.

The yellow and magenta separations are organized into columns. The first five columns (nine color patches to a column) are printed with 100% yellow ink. The remaining columns are 95%, 90%, 85%, and 80% respectively. The magenta separation is just the opposite. The first four columns are 80%, 85%, 90% and 95%, with the remaining columns produced with 100% coverage of magenta ink. Dot percentages are labeled above each column in Diagram 3.

The pattern for the cyan and black is set up in rows. Working from top to bottom the rows of color patches are created with the following values of 20%, 15%, 10%, 5%, 0%, 5%, 10%, 15%, and 20%.

The dot percentages used to create the black separation, set up from top to bottom are as follows; 20%, 15%, 10%, 5%, 0%, 0%, 0%, 0%, and 0%. Dot percentages are labeled on the sides of each row in Diagram 4.

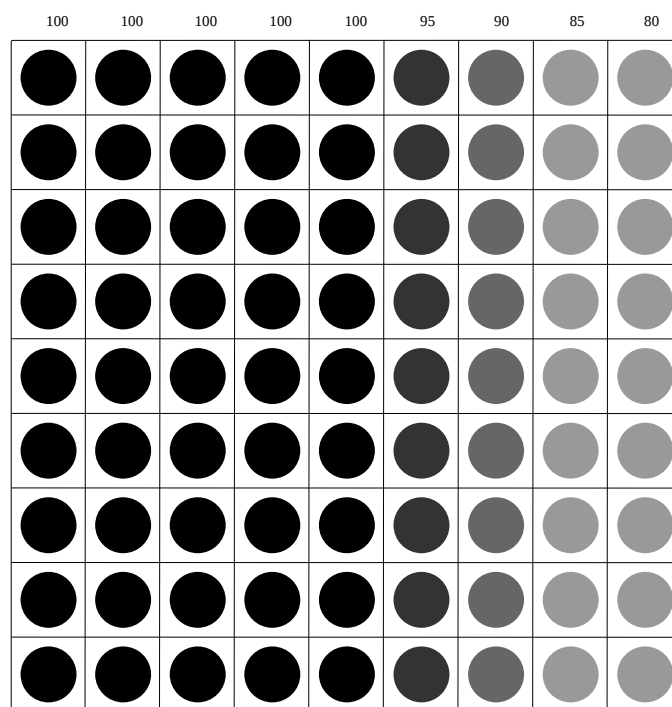


Diagram 3.

Columns of color patches right of center created with decreasing amounts of yellow from 95% to 80% in 5% increments. All other color patches printed 100% yellow.

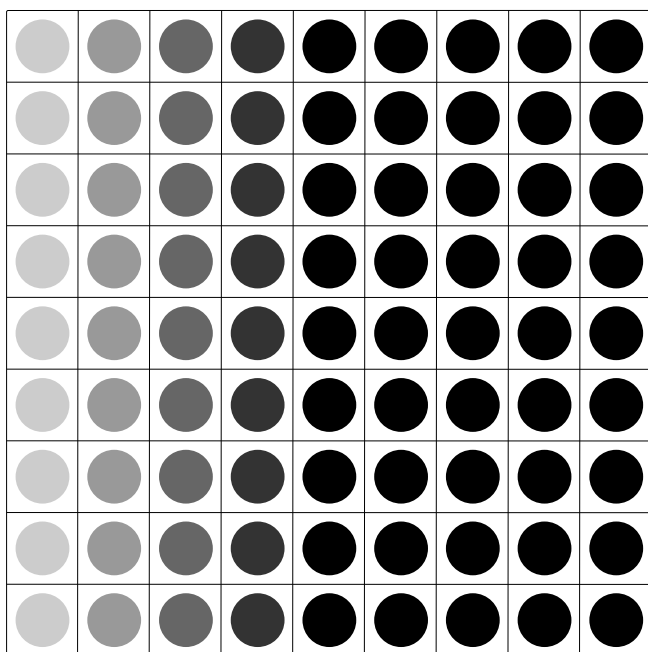


Diagram 4.

Columns of color patches left of center created with decreasing amounts of magenta from 95% to 80% in 5% increments. All other color patches printed 100% magenta.

How to Proof the SCG

A computer file of the SCG is sent to an image-setter and a set of four-color separation films are produced. The first proof will be exposed using a traditional proofing order by matching the color indication on the separation with the color of the proofing material. The remaining SCGs will be

created by mixing the separations and proofing materials. Relabeling of films may be necessary to eliminate confusion during the exposure process. When completed there will be three different color guides created from one set of separation films.

First SCG:

1. Expose the magenta separation to the magenta proofing material.
2. Expose the yellow separation to the yellow proofing material.
3. Expose the cyan separation to the cyan proofing material
4. Expose the black separation to the black proofing material
5. Process the proofing materials to create the first SCG.

The next guide will stray from traditional methods by mixing up the separations during the exposure. The separations films will be exposed to proofing material that do not match the color indicated on the separations.

Second SCG:

1. Expose the magenta separation to the yellow proofing material.

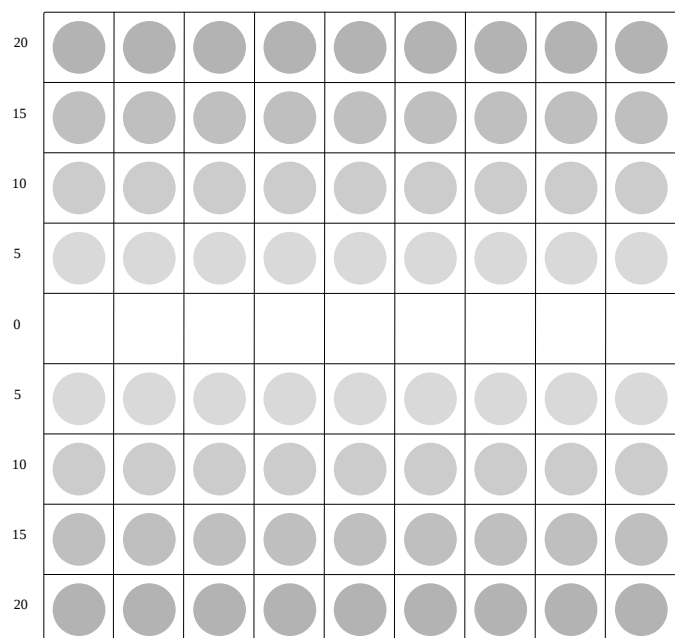


Diagram 5.

Dot percentages of cyan separation increase from 0 to 20% in 5% increments, from the center row out. Center row of color patches contains 0% cyan.

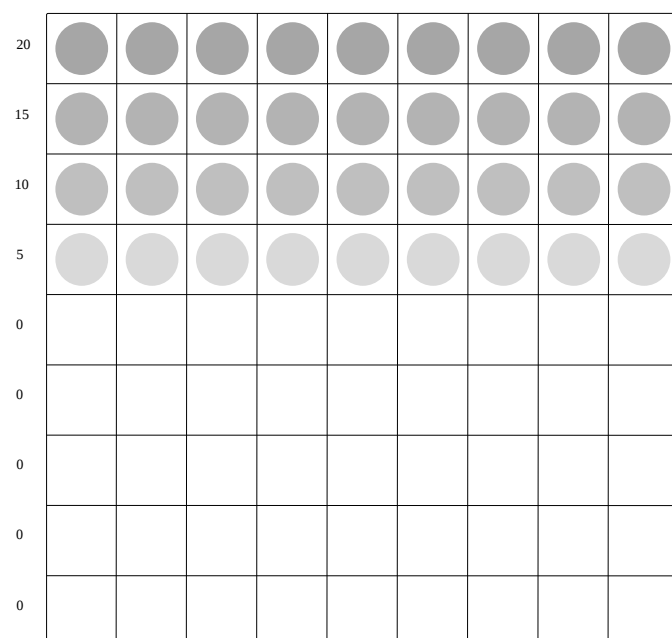


Diagram 6.

Dot percentages of black separation increase from 0 to 20% in 5% increments. All other color patches contain 0% black.

2. Expose the yellow separation to the cyan proofing material.
3. Expose the cyan separation to the magenta proofing material.
4. Expose the black separation to the black proofing material.
5. Process the proofing materials to create the second SCG.

This final SCG will again mix the separations and films to provide a completely different film and proofing combination.

Third SCG:

1. Expose the magenta separation to the cyan proofing material.
2. Expose the yellow separation to the magenta proofing material.
3. Expose the cyan separation to the yellow proofing material.
4. Expose the black separation to the black proofing material.
5. Process the proofing materials to create the final SCG.

Remember, the black separation is never switched. The separation film labeled black is used to expose the black proofing material for all three SCGs. It remains the only separation that is not rotated during the exposure cycle.

Since the target has no written definition, the color of the patches define the color of the guide. The red guide will have red patches, the green will have green patches, and the blue SCG will be indicated by the blue color of the patches on the guide.

One final note that will assist in the construction of the SCG. Because three different guides will be created with one set of separations, the placement of the yellow dot values will change. For the red SCG, the yellow will be in the upper right hand corner. For the cyan SCG they will move to the upper left hand corner. For the green SCG, the yellow number will drop to the lower right. Because of the difficulty in viewing yellow type and because of the mixing of the separations and proofing materials, the place-

ment of the yellow dot percentages will vary between the different SCGs. It will be important to darken the yellow dot values slightly. To accomplish this, add 15% black behind all values that represent the colors of yellow, magenta and cyan. The darkened values of yellow will be easier to see and the addition of 15% black will go unnoticed under the magenta and cyan color patch dot percent indicators.

How to Use the SCG

1. Select the appropriate guide to compare with a color in question.
2. View the guide and the original under the appropriate lighting conditions of 5000°K.
3. Locate an accurate match by comparing the original to the guide.
4. If an accurate match is obtained, the color in question can be reproduced with this printing system. Using the appropriate dot values surrounding the color, determine the dot percentages required to reproduce this chosen color.
5. If it is not possible to match an original to a select color patch, the color in question is outside the color gamut of this printing system. An alternate printing method will be required to obtain an accurate reproduction of this color.

While the SCG's primary function is the ability to predict the outcome of a separation, its role can be easily expanded. Novice scanner operators typically have difficulty in judging the intensity and dot values of secondary colors. The SCG provides a visual reference to show the operator what secondary colors are possible within the color gamut.

The SCG also provides an opportunity for an instructor to introduce the student to the concept of a fifth color "touch plate." If a client needs to understand why their product or original can only be reproduced with the use of a fifth color, a simple inspection of the SCG is sufficient. A color that cannot be matched with the SCG will require an additional color to match the original. A "touch

plate” is a method of color matching that includes the addition of a fifth color to extend the range or color gamut of the printing process. This method of extending the printing gamut is sometimes the only way to match the original.

Training and Education for the Future

Complete sets of the SCG will be helpful anywhere color is judged within the graphic arts industry. Education, sales and saleservice personnel will all benefit with this resource to prejudge the ability of a given printing process to reproduce a particular secondary color. Scanner and color correction personnel can use the guide to visually judge the

accuracy of dot values of both originals and previously scanned files for color correction. The SCG will be an important instructional tool for any color operation.

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Digital Video: A State of the Art Report

by Chris Lantz

Electronic images have been used in publishing for many years. These images have been primarily static or still images such as scanned photos, images from digital still cameras, or PhotoCD. Graphic communications educators are increasingly thinking of imagery in broader terms such as digital movies, for integration into published multimedia titles or web sights, because this has become an established market in many new media publishing houses. The ease of use and low cost of entry-level digital video has made video production accessible to many educational users who have never produced video before. Concepts related to scripting, editing, and the language of film will become important basic skills for many of these first time users. This situation is similar to how the widespread adoption of desktop publishing in the 1980's has made page design and layout important subjects to a wider spectrum of users.

Digital or non-linear video allows moving images and sound to play in almost any document or application on the Apple Macintosh or IBM computer and it has become a standard part of the operating systems on both platforms. Apple Quicktime movie files can be cut and pasted, imported, and edited just as any another general graphics or text Macintosh file format can. IBM PC based AVI (Audio/Video Interleaved) files can also be edited in digital video applications and used within standard graphics applications. Many different types of photography and conventional video can provide realistic images, but only digital video can provide sound and motion in addition to random accessibility, no loss of quality when copied, widely flexible computer-generated special effects, and incorporation into other computer-based presentation programs.

Advantages of Digital Video

The random-access capability of digital video makes any point of a video program instantly accessible without waiting for videotape to rewind or fast-forward to a specific point. Random accessibility is essential for the integration of video clips into instructional computing applications such as interactive instruction and self-paced learning. The very fact that any portion of a video production can be instantly accessed at a point in interactive instruction where a learner selects it is significant in itself. Another main advantage of the digital video format is that it is so easily manipulated for special effect or enhancement of the video picture. The same special effects that until recently were only available to a commercial producer are now available to the limited budget, educational video producer.

Another advantage of digital video is that the same video editing software program can be used at low resolution with low cost computers, or, with additional hardware and memory, full screen digital video is possible. Once the basic editing is completed, no loss in quality is incurred, as it would be if multiple VCR's were used in traditional editing. The digital files can be copied as many times as needed without a loss at each generation. The editing program can also output the movie in several resolutions once the editing instructions are complete without duplication of editing commands.

Digital Video in Educational Multimedia

Recent developments in multimedia computer technology have had significant impacts on educa-

tion and corporate training. Distance learning, interactive instruction, and educational television have enriched the traditional classroom, and, in some cases, even replaced it. One of the most promising of the emerging technologies is digital video. Educational video is often produced in short clips which are designed to be included in instruction at a particular point. These shorter clips are an ideal application of the digital format. Video clips are also often supplemented by titles and other graphic elements as part of interactive instruction or presentation graphics. Producing digital video on personal computers does have some distinct disadvantages that are detrimental for longer, Hollywood-style productions, but they are not often a factor for many instructional applications.

Individualized instruction is a common application of the digital video format. School media centers have been involved in the production of individualized instruction for many years. In the past, individualized instruction programming involved film clips which were accessible to students with the aid of film loop projectors. Video discs became available in the mid 1980's, and student selection of video clips within instruction was assisted via computer. The use of video clips in individualized instruction went one step further when digital video was announced. Digital video clips were initially integrated into existing instructional programs such as HyperCard stacks and then later into presentation programs and interactive multimedia delivered first by CD-ROM and later via the Internet.

Computer presentations are often produced for display over video projection systems in large lecture hall classrooms. Many universities have switched from traditional photographic presentations to computer-based ones for many applications. Although there are still some distinct resolution advantages to the 16mm movie, the low cost, convenience, and speed offered by digital images are often crucial. Several colleges and universities, as well as a few high schools, have constructed permanent electronic classrooms for teachers to display computer-based presentations. Another approach is the creation of mobile carts which

contain a computer and video projectors which faculty can use in a traditional class setting to project visuals on a standard screen.

Apple Quicktime

The original digital video format, Quicktime, was introduced by Apple in 1992. Quicktime evolved from a "Dicron" or dynamic icon developed by Apple and the "Micron" or movie icon created by programmers at Massachusetts Institute of Technology. Dicrons and Microns were simply intended to be interesting and unique program or file icons. These icons played the contents of a movie within a tiny postage stamp size window after being selected by the mouse. Quicktime version 1.0, released in December 1992, was the size of four postage stamps (160×120 pixels) and was able to display movies at 15 frames per second. The present version of Quicktime has a standard picture size of 320×240 pixels and is able to display movies at 15 frames per second unassisted by hardware compression. Quicktime may also be assisted by hardware boards to produce full screen size images (640×480) displayed at 30 frames per second.

Quicktime is unique in its lower resolution sizes because it is a purely software based system that doesn't require the purchase of additional hardware in order to play movie files. This software-only approach was brought about by the invention of very efficient computer file compression. Quicktime also takes advantage of the Macintosh's ability to use dependent files. A dependent file is created when multiple digital video clips are edited in the computer. This dependent file takes up almost no memory resources in the computer because it simply points the computer to play parts of the original clips that a movie was edited from without duplicating such files to create the new edit.

At the time of Quicktime's introduction, computing speed and memory were both inadequate and very expensive. With the introduction of the Macintosh Power PC chip-based computers, a new faster version of Quicktime became available. The increase in speed has eliminated some of the quality prob-

lems present in earlier digital video productions, such as slow frame rates, dropped frames, and visible compression pixelation.

Quicktime VR

A more recent Quicktime digital video innovation is the “navigable” or Quicktime VR movie, in which the viewer can direct movement of an imaginary camera through a scene. The viewer points an arrow cursor at the movie clip itself, and by clicking and dragging the mouse toward a new direction, the digital video program instantly retrieves image data which corresponds to the new direction (Figure 1). This enables the viewer to scroll around the scene at will. Quicktime VR movies are based around one large wraparound still picture (Figure 2), and because it is not made up of the hundreds of frames of conventional digital video, its file size is very small.



Figure 1. The viewer can drag a cursor (left) or zoom in (middle) in order to navigate within a Quicktime VR movie (right).

PC Based MJPEG and MPEG

There are many more competing and complementary digital video file format standards for a Microsoft Windows based computer. Some digital video producers claim that Macintosh has maintained a strong lead over the Windows based computers for digital video because Quicktime was available first and had fewer software and hardware factors to learn and configure. In order to edit video on a PC, the most common method is to use a MJPEG digitizing board which fits into a PCI card slot of a Pentium-class computer. This board uses hardware based Motion Joint Photographic Experts Group (MJPEG) compression of the incoming video source, but the actual file created from such a board is AVI or the Audio/Video Interleaved format. The AVI files can

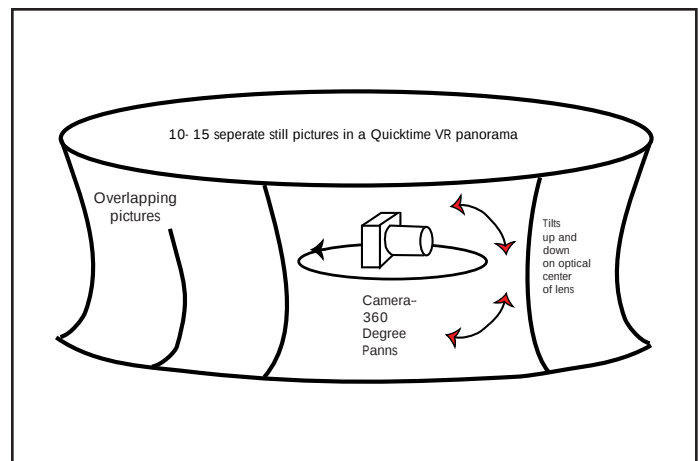


Figure 2. Procedure for photographing a Quicktime VR panorama.

then be edited on one of the many video editing programs available for Windows, such as Adobe Premiere. Such a resulting final edited AVI file can then be converted to the Motion Pictures Experts Group (MPEG) format. AVI is converted to MPEG because such files can be played back on computers which have MPEG playback hardware. This MPEG hardware is included with most Pentium computers which claim to be multimedia capable. For computers that do not come from the factory with such an MPEG playback chip, it is available as a common upgrade board available for most Pentium class computers.

MPEG has rapidly become the default movie distribution format on the Internet and for many CD-ROM applications because MPEG files can be played by both Mac and IBM computers. The main disadvantage of software based MPEG is that it is incapable of producing a full screen picture. An MPEG-1 hardware board solves this problem and is able to play the 74-minute Video CD format via a CD-ROM drive. The first MPEG-1 decompression playback-only hardware board was the Sigma Designs Reel Magic introduced in 1993. The Video CD may die in its current experimental format as it is replaced by the newer standards. Currently Video CD can only be read on CDI home players and computers with MPEG-1 hardware and CD-ROM drives.

High density compact discs (HDCD) are replacing the fledgling Video CD. HDCDs can store 7.4 gigabytes or 270 minutes of full screen digital video in the MPEG-2 format. The MPEG-2 format has a high 720×420 resolution. The technology to master

compact discs of much higher capacity has been available for several years. What has been lacking until now are standards for the use of these discs for the high density CD-ROM and consumer video markets. Time-Warner and Toshiba have introduced the Digital Video Disc (DVD) as a new consumer video format that uses this high density compact disc technology. MPEG-2 chips are already incorporated into recent multimedia PC computers. With the success of these MPEG-2 formats, it could be a common occurrence to rent a full screen movie for the computer or Digital Video Disc Player. A parallel development could be that a writeable DVD may be the next generation consumer video recorder/player replacement for VHS. The current Video CD and DVD formats are read-only discs that can't be re-recorded.

The next MPEG standard (MPEG-4) is already on the drawing board and promises to offer many new features that are of interest to multimedia developers. This includes a video track structure which is similar in versatility to the MIDI format used by professional musicians. With the MIDI format, it is possible to automatically synthesize the same tune played on many different instruments. With MPEG-4, it will be possible to select out various subjects in images and play them through other environments such as a distinct object in three-dimensional space. Developments such as MPEG-4 confirm that digital video will be the driving force behind the future success of virtual reality technology.

Resolution and Compression of Digital Video

A pixel is the smallest picture unit or element from which images are made on both computer or television screens. The size of a typical low resolution digital video screen is 160×120 pixels versus the resolution of a computer monitor which is 640×480. As a result, the pixel area defining the digital video picture playable on low-end computers is significantly lower in resolution than a television or computer monitor screen. This is because moving pictures display 15–30 still pictures per second to achieve the illusion of motion. Although almost any

current Macintosh or IBM computer will run basic digital video movies, the more expensive models, which feature greater memory and computing speeds, are required for editing and manipulating long length and high resolution scenes. The quality of the image is further impacted by software compression. Spatial compression works by analyzing the picture and subtracting resolution from the image where little detail exists. Temporal compression only records information that is different from one frame of video to another, thus avoiding the storage of the same information multiple times. Compression cannot be detected if used to a small degree. But if video is greatly compressed, large blocks of pixels, which make up the image, become visible and frames are lost, making the video playback seem jerky. Even when the size and resolution of the video image is lowered, only a few minutes of video will fit on most lower-cost computers. Advances in digital storage technology have improved this situation through the availability of writable optical discs CD-R (640 megabytes) and high capacity removable hard disks such as the 1 gigabyte Jaz drive.

A high degree of compression and decompression (CODEC) of digital picture files has made the digital video format possible. This CODEC technology has been applied in the transmission of images for distance education applications over standard phone lines and has made the installation of expensive fiber optic cables unnecessary in many sites. Depending upon what amount is applied, compression can significantly lower the resolution we expect to see on television. One of the main limitations of digital video is the speed at which picture information can be compressed and decompressed. This compression is completed by the digital video software itself as a movie is captured into the computer and when a movie is played on the computer. When playing a digital video movie, one frame at a time must be decompressed for viewing. This decompression on-the-fly requires a fast and memory-laden computer to maintain a normal frame rate that doesn't flicker on the screen like a 1920's movie. One way to remove these restraints is to use a piece of hardware which is dedicated to CODEC. These boards allow

movies to be created and viewed at much higher resolutions than software-compressed digital video. Desktop video systems that use compression boards or hardware add-ons dedicated to digital video compression are now common in the form of MPEG hardware, as described in the last section. MPEG has made full television-resolution images playable on low cost computers.

Getting Video Into Your Computer

You can make your own digital movie files by inputting or digitizing live video or videotape. Digitizing is the conversion of video scenes on the videotape format into a file within computer memory. This digitizing is accomplished by computer add-on hardware such as a board that resides within a computer, a small digital camera such as the Connectix Quickcam (Figure 3), or with aid of the new digital video camera interfaces such as Firewire. Firewire is a digital video cable connection provided on Digital Video Cassette consumer camcorders. This connection provides a direct link between the data on the digital video cassette and the computer. Such a direct digital connection is bound to be the input method of choice in the future when it becomes more of a standard feature. However, the most common current method for digitizing video uses a conventional videotape player or camcorder directly connected to a digitizing board. After the video is digitized, the information which makes up the movie can be edited, and a great number of special effect possibilities can be utilized in a presentation. Low resolution digital movies are most commonly distributed via CD-ROM, and the Internet. High resolution digital movies can be recorded on Digital Video Disc or played back real-time via a high performance server. The latter technology has brought about the movie-on-demand features of the small dish home satellite receivers.

Low Resolution Video Conferencing

A new category of video digitizing appeared with the introduction of the Connectix Quickcam (Figure 3). In addition to being a low cost digital movie making

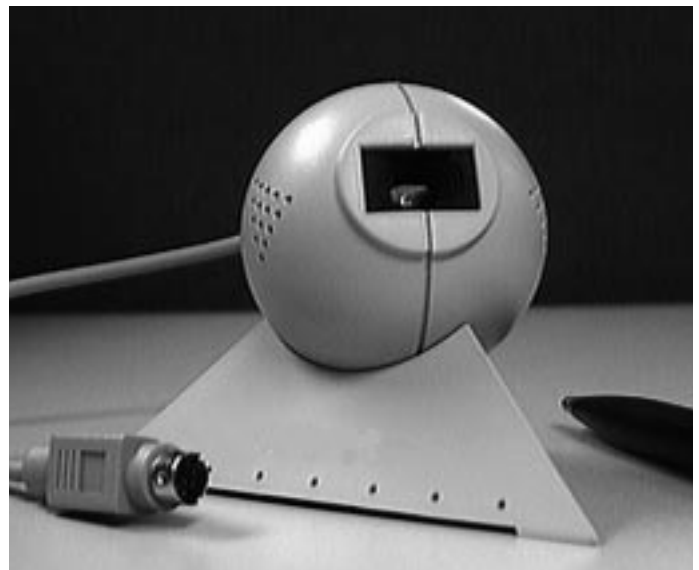


Figure 3. The Connectix Quickcam digital camera.

system, the Quickcam is also used for video teleconferencing between sites in the same building, over a local area network, or over the Internet. A shareware program called "CU-SeeMe" can be used to provide Quicktime teleconferencing capability to the Macintosh or Windows environment. The main barrier to computer teleconferencing in the past was the need for a camera, video digitizer, and expensive dedicated compression and decompression (CODEC) hardware at each site. CU-SeeMe provides the software CODEC and the Quickcam serves the function of a digitizing board, microphone and video camera for \$100 per site. Two Quickcams can be purchased for two-site teleconferencing, or existing video cameras and digitizing boards may also be used to connect to Quickcam users. The image produced by the Quickcam is black and white, small in size, low in resolution, and blurry when compared with that of a standard video camera, but it is often quite adequate for teleconferencing purposes, as in Figure 4. The Quickcam is well matched to its application since the resolution capacity of digital video teleconferencing is just slightly greater than what can be produced by the Quickcam anyway. The Quickcam can be used without a separate hardware board because digitizing is accomplished with a custom microprocessor chip in the camera. This digitizing microprocessor enables a direct connection from the camera to the serial printer or modem port on the computer.

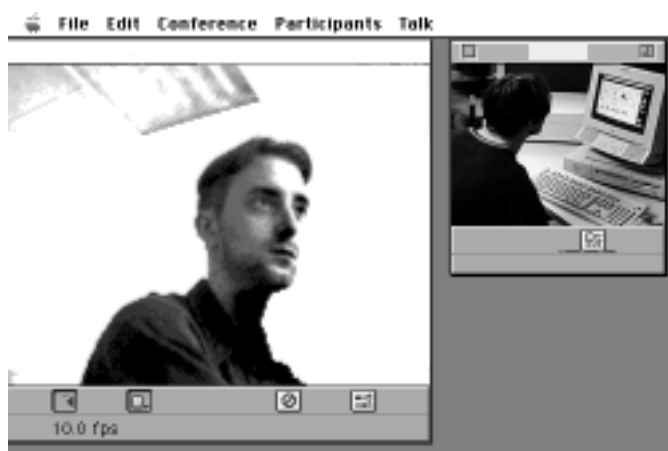


Figure 4. The CU-SeeMe program and Quickcams are used to facilitate a teleconference between two different sights in the windows above.

Digital Video Editing Programs

Most digital video editing programs have a very similar basic structure. Editing is performed by dragging and dropping the icons representing movie clips from one window to another. One window acts as a holding bin in which to import the various video and sound clips which will make up the production. The other main window acts as an assembly point where clips from the holding bin are dragged and dropped in the desired order (Figure 5). If some of the clips need to be trimmed before they are dropped into the assembly window, this is accomplished simply by double clicking on their icons in the holding bin and performing the necessary adjustments with a standard playbar

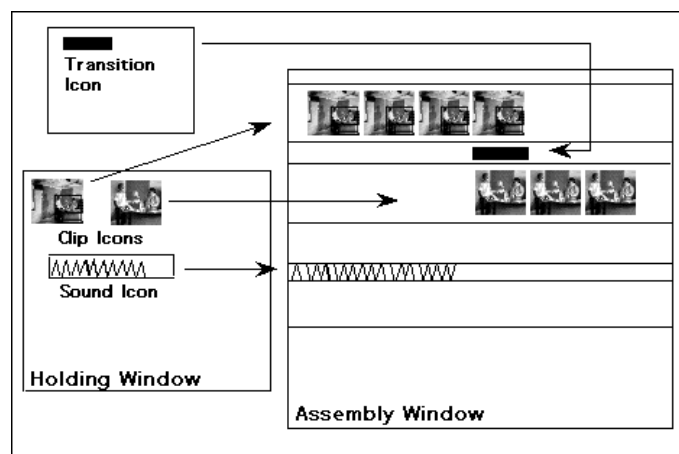


Figure 5. The basic window structure of a digital video editing program is "drag and drop" in the sense that icons representing movie clips, sounds, and transition commands can be dropped into the assembly window.

controller window. The standard controller window consists of the common components in Figure 6.

Once the clips are dragged and dropped from the holding window to the assembly window, the movie is made by using a command such as "compile movie."

The real advantages of drag and drop programs become apparent when some of the advanced functions of the assembly window are used. Additional icons can be added to the assembly window which represent transition effects. Such transitions are simply dragged and dropped into the assembly window between scenes. Individual scenes can be selected in the assembly window by simply clicking on them with the mouse. Once scenes are selected, any number of digital filters may be applied to them by using a menu of options. Such filters can perform corrections such as density and color balance, or they may produce an array of special effects. Special effects include various distortions and patterns which are applied to the length of the selected movie clip. Another feature of the assembly window is the ability to add additional video and sound tracks. The effect of various simultaneous music, narration, sound effects, and dialog sound tracks can all be modulated in sound level throughout the length of a clip. The icon representing a sound can also be selected and effects filters can be added. Sound filters include basic gain correction in addition to echo or backwards play special effects. Another type of video track provides the ability to create superimposition

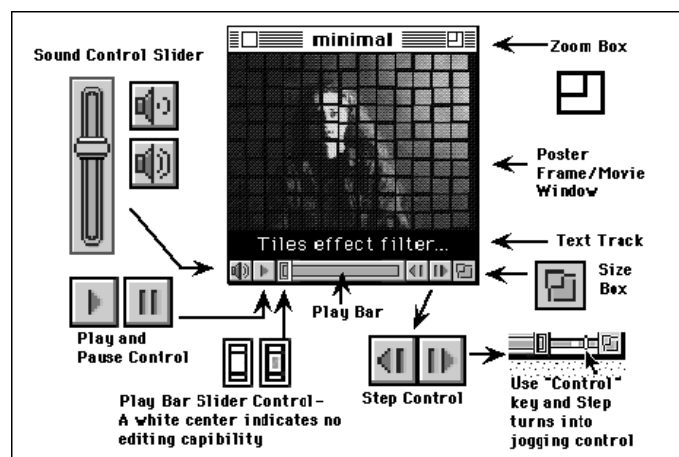


Figure 6. Components of a standard digital video controller bar (in this case on the Macintosh computer).

effects. A weather caster superimposed over a weather map is a common example of an application of this track. All of these editing programs also have titling features.

Output to Videotape

For many applications, a completed digital video production is destined for use within a computer, and no output to tape is necessary. If the producer wishes to output a digital video to the wider videotape market, the digital signal must be converted to analog NTSC (National Television Standards Committee). Standard resolution digital video will be quite unimpressive on videotape because of its low resolution. The full screen size digital video systems output an acceptable NTSC full screen picture to tape, although these are still relatively costly. The process of outputting to tape can be accomplished by rendering a few frames at a time. This rendering provides the highest quality output and is not restrained by the speed at which the computer can present frames to be recorded. Outputting to tape will be less common as the popularity of directly recording digital video data to CD-ROM or other compact disc formats increases.

Digital Effects

The special effects possibilities available with digital video are almost endless. Image altering filters, complex transitions between scenes, multiple superimposition of video and audio tracks, and movement of picture elements are possible even with standard digital video editing programs such as Adobe Premiere. One of the most common digital movie effects are filters. A digital filter is a program that transforms and rearranges the pixels or picture elements that make up a movie. Adobe Premiere has 50 such filters. A few examples of special effects filters are provided in Figure 7. Additional filter sets can be purchased or they can come from other programs such as Adobe Photoshop. “Extrude” and “Wind” are examples of two filters that can be dragged out of the Photoshop filters folder into the

Premiere filters folder. The transformation of pixels can take the form of simple corrections such as “Brightness and Contrast,” or they can be more fanciful such as with “Zigzag,” “Ghosting,” or “Pointilize.” The assigning of a filter command to a clip is a simple matter of selecting the clip, using a “Filters” command and selecting the desired filters (several can be used at one time). A razor blade tool found in the construction window toolbox of Premiere can be used to isolate a portion of a clip for filtering.

Another common digital movie effect is superimposition. The superimpose track in Premiere, for example, provides a means in which to play one video source through a selected area of another video source. The image placed in the superimpose track will play through an area defined in video tracks A and B. This area is defined with the “Transparency Settings” controls. One way to think about the superimpose feature is that of two overlapping cards. The top card corresponds to the video and the bottom card is the source in the superimpose track. The transparency settings act as a pair of scissors which cuts out a portion of the top card to reveal the bottom card underneath. Simple geometric shapes can easily be defined as the area for the superimpose image to play through. The selection of more complex areas with the transparency settings is called keying. Keying methods, such as chroma, are

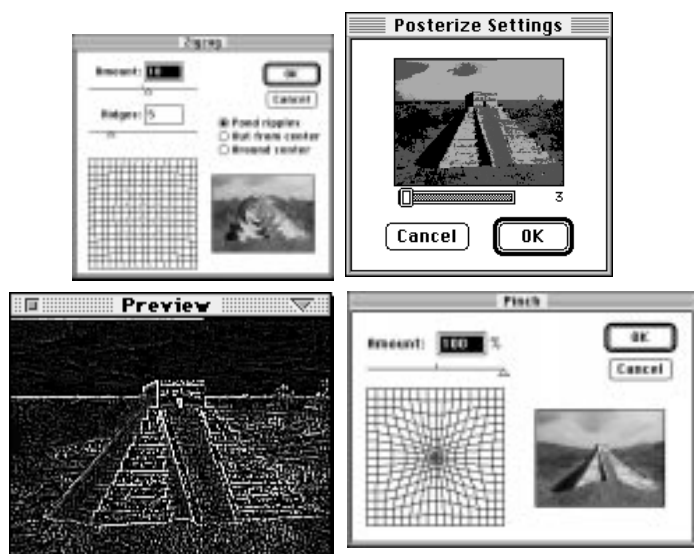


Figure 7. Pinch, zigzag, posterize, find edges and pinch special effect filters.

clever ways in which to select complex areas. Chroma key is one of the most common keying methods. With chroma, you select only one specific color for the top card video source. This is often a special blue color that does not exist in the rest of the scene. If areas exist anywhere else in a scene that match the keyed color, these areas will leak the superimposed source through. The bottom card superimpose source will play only through this color. Videographers can include a uniform color tone in the scene (top card) which is keyed for the other superimpose (bottom card) video source. The source imagery that can be placed in the superimposed track includes still pictures, titles, and movies. Titles are a typical use of the superimposed track where the white background of black letters can be keyed for the clip in track A and B to play through (Figure 8).

Motion tools are another fundamental effect possible with digital video (Figure 9). Motion tools set flexible motion paths that can be used with any clip. A typical example is a moving title superimposed over another movie clip. The motion controls can just as easily be used to set a graphic, video, or still picture into motion.

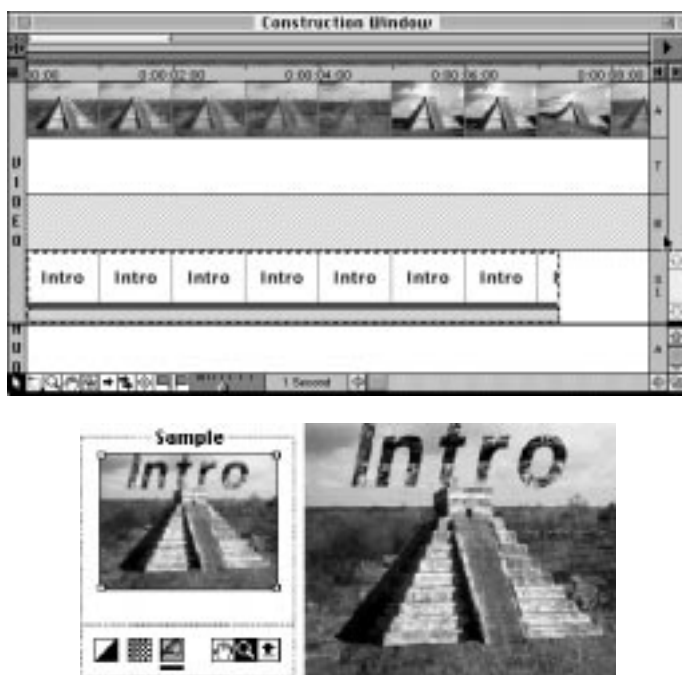


Figure 8. The superimpose track (S 1) can be used to float a title over a video clip as in the bottom image

Teaching Digital Video

A possible danger of all these new digital special effects is their possible overuse. When still picture effects first became possible with programs such as Photoshop, some had a tendency to overuse them.

The same dangers exist with new digital video producers who may put more efforts into the tools than the message or content being communicated. As with most media production tools, digital video is meant to enhance production and not to call attention to itself. This is often really hard to do when a whole new set of production options appear in only one or two years as they did in the case with digital video.

Although several different digital video software applications exist, they all share the same basic interface. Each software product exploits these capabilities in different ways, depending upon their target consumer, but none of the products have completely different operating principles. This means that if students learn to use Adobe Premiere software on a very inexpensive computer system, they have mastered the majority of tools that are used on the most expensive desktop computer systems. The difference is that on the more expensive systems, the software is actually much easier to use since it runs many times faster and can preview an effect or compile a

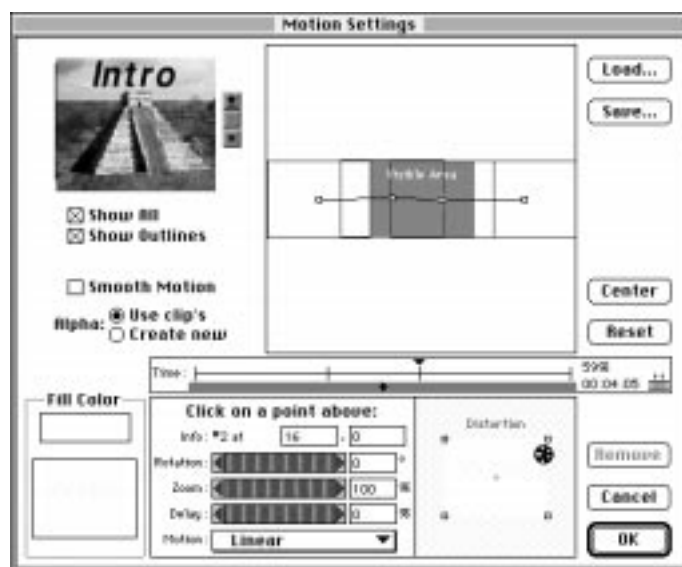


Figure 9. Motion settings window. The line in the center of this window is the motion path on which a title or another video clip can be set into motion.

final movie much more rapidly. This has been a boon in teaching digital video because the principles are applicable to a wide range of production practices that a student may find in the marketplace.

Even though conventional videotape editing systems do share similar configurations and basic steps of operation it is still much more risky to generalize about the operation of one piece of tape editing equipment compared with that of another. Different brands and models of videotape editing equipment have their own proprietary names and capabilities. The fact that digital video is built around the same digital file format standards is helpful from a teaching standpoint in flattening the learning curve. Software developers have recognized the vast possibilities of the digital video formats as is reflected by the wide range of software products that have been developed in such a short time. By studying the rapid improvement and adoption of the non-linear format among professionals, it is easy to predict the total demise of conventional videotape. This has

taken place first for commercial post production and is starting to make an impact on mass market consumer video.

Conclusion

Despite the seemingly complex options that desktop video offers, the reality is that video editing and production for the end user in education is greatly simplified. A conventional videotape editing suite consists of multiple VCRs, monitors, controller consoles and scores of cables and hook-ups. A digital desktop video system consists of a conventional microcomputer, a Quicktime or AVI based software application, and a digitizing board. Essentially all the hardware components in the conventional editing system are emulated in the software application, rendering them less complex for many when compared to traditional videotape production.

The Revitalization of a Traditional Graphic Communications Program: A Case Study

by Mark Snyder

The field of graphic communications has had its place in the history of the Pennsylvania College of Technology since nearly the turn of the century. The program has been housed in four different locations and was moved to its current location in 1989 upon completion of the new structure. In 1994, the unexpected death of a faculty member and the retirement of another presented the Graphic Communications program with a sudden setback. Although the program was unsettled for one year, the College approached the setback as an opportunity to review the program and make a decision on its future direction. This effort resulted in a course of action which involved four general phases: program review, needs assessment, curriculum development, and facility planning. The following is a record of the events involved in the revitalization of the program and the establishment of a new baccalaureate program in Printing and Publishing Technology.

Background

Pennsylvania College of Technology has a long history of offering technology-based instruction. The origin of the school dates back to the Williamsport High School of the nineteenth century. In 1914, following World War I, the high school industrial facilities became home to adult education programs that served veterans who needed immediate retraining. During the era of the Great Depression in the 1920's and 1930's, the "Williamsport Plan" emerged as a model for retraining that was copied throughout

the United States. The school was officially established in 1941 as the Williamsport Technical Institute and in 1965, the Institute was re-established as the Williamsport Area Community College. In 1989, the Pennsylvania College of Technology was founded as an affiliate of The Pennsylvania State University. Today it is a unique institution offering bachelor and associate degrees and specialized educational opportunities focused on applied technology. Penn College is an integral part of the Penn State system, offering students the opportunity to combine a hands-on, technical education with theory and management education.

Program Review

The process of reviewing the Graphic Communications Associate of Applied Science (AAS) program began in May of 1994 with an Advisory Committee meeting. The Review Committee was chaired by the Assistant Dean of the Integrated Studies Division and consisted of all faculty of the Communication Arts Department. The Review Committee met approximately fifteen times during the following year and the final report of the Program Review was submitted in June, 1995. The College Director of Outcomes Assessment also contributed to the process by participating in almost half of the meetings and moderating focus group meetings with students. During the process, staff from the College in-plant printing unit also contributed valuable perspective to the discussion.



Figure 1. Aerial View of the Applied Technology and Health Sciences Building

The initial step down the path to program revision was the first of two Advisory Committee meetings. After introductions, a tour, and the delivery of program information, the Advisory Committee members lent their insights into long and short-term industry trends by responding to specific questions prepared by faculty. They cited the transition to digital imaging and page layout technologies as well as the rapid growth of full-color process printing as primary technological advances. They suggested that money spent on repairing obsolete equipment would be better spent elsewhere. As for new equipment, the advice was to buy from a variety of major manufacturers, make sure that the equipment is readily networked and upgradeable, and buy service contracts whenever possible.

The Advisory Committee members also shared their visions of competencies and characteristics that would distinguish graduates as being very employable. It was felt that, in addition to general education requirements, students should develop a thorough understanding of computer systems and their applications, color theory, elementary statistics applicable to quality control, paper and ink properties, environmental issues, and technical terminology. In this discussion, it seemed that specific psychomotor skills were de-emphasized in favor of the development of interpersonal skills, communication skills, and the

general ability to “move a project from start to finish.” Identified affective behaviors included dependability, independence, loyalty, self-motivation, and the willingness to solve problems. Overall, a general understanding of the entire process of printing production was preferred over specific training in one trade skill.

Other questions concerning personnel issues focused on the demand for graduates with an associate degree in graphic communications. There was a consensus regarding employability—nearly any worthy graduate should be able to get a job within the broad realm of the printing industry. An associate degree in graphic communications allows immediate entry into a more skilled position and a slightly higher entry-level salary than someone without the educational experience. It was stated that, typically, it would take 6–7 years for a traditional graduate of an associate degree program to move into a supervisory position.

Finally, the Advisory Committee reviewed the existing graphic communications program and commented on curriculum revision possibilities. Recommendations specific to the content area included the inclusion of screen printing; the addition of finishing and bindery courses; classes related to imaging technologies needed to be updated; paper and ink need to be studied more thoroughly; and graphics

students should be required to take at least one course in design principles. An internship was strongly recommended to offer more experience and further increase the employability of graduates. Also, flexography and gravure were considered good areas for future expansion, but not essential.

In regard to student work, research assignments were stressed as very important and portfolios were thought to be useful. Other useful outcomes from the Advisory Committee meeting included information on how to pursue donations and suggested methods to improve the image and the marketing strategy of the program.

Following the Advisory Committee meeting, the Review Committee began a number of tasks in the process of determining the status of the program. Through subsequent meetings, the Review Committee identified a complete inventory of equipment used in the program. The department head also inventoried library holdings in support of the program to determine their adequacy.

The Review Committee then analyzed the thirteen program objectives listed in the 1994 College catalog and determined that many of those objectives were no longer relevant. As a result, five “key” points (pre-press, imaging, assembly, press operations, and interpersonal relations) were analyzed based on the following criteria: courses that met each objective, staffing expertise, adequacy of facilities and equipment, measures of student achievement, levels of proficiency, and areas in general need of improvement.

In February, 1995, a student focus group activity was organized to assess student opinions of the program and the stated objectives. Both first and second year students were polled for responses to questions to determine accessibility of equipment, use of equipment, use of labs, use of library materials, time spent on class work, accessibility of faculty, quality of instruction, and general perceptions of the program. Students participated by orally responding to the questions prepared by the Committee and presented by an impartial moderator.

Other resources utilized for the program review included graduate surveys, employer surveys, grade

distribution sheets, sourcebook data, and enrollment trends. The final report of Issues/Recommendations for the Graphic Communications Program fell into four general categories that were considered of primary importance: the overall curriculum, facilities and equipment, staffing, and program promotion. The issues and recommendations as listed in the report are as follows.

A. Overall Curriculum

- Program objectives are focused on psychomotor skills—revise them to represent cognitive and affective areas of learning.
- Program objectives also need to relate to modern technologies, especially digital systems—update objectives.
- There is a need for internships, preferably paid—consider as something to add in curriculum revision.
- Most courses focus too much on specific skills—develop courses that provide more opportunities to move jobs from start to finish.
- Transition to new technology—maintain appreciation for technology by teaching historical development.
- Need to include finishing operations—integrate instruction or add courses in area of finishing and binding.
- Need for diversity (more printing processes)—examine the addition of screen printing.

B. Facilities and Equipment

- Facilities are modern but do not utilize the ample space efficiently—develop a “dream layout” for the west wing (particularly the center portion) and consider adopting a commercial model.
- Need to acquire modern technologies—develop and sustain a five-year plan for equipment replacement. Pursue donations aggressively.
- Facilities are “sterile”—add wall furnishings to display student work and program activities.

C. Staffing

- Immediate need for full-time faculty—fill two available faculty positions.
- Need for effective use of part-time staff—examine the use of “paraprofessionals” and lab assistants. Build into five-year plan.
- Past faculty were very specialized—maintain commitment to hiring generalists.
- Faculty need to be adaptable—allow for visits to industry, professional seminars, and so on to keep faculty abreast of technological advancements.

D. Program Promotion

- The school/program is a well-kept secret—improve program visibility.
- Market the program—develop program materials, in particular, a brochure.
- Market appropriately—focus on the value of the program first, then the College.
- Continue Communications Day—every other year hold an open house for regional high school/vocational students.

Overall, the program review lasted slightly more than one year. Although the process was focused on review, it was organized so as to plan for efficient curriculum development. The procedures were thorough and were carried out completely. According to the Assistant Dean, in her final memo regarding the review, “although this was significant work, the activity was pleasantly collegial and allowed for interactions that too often do not happen because of everyone’s being too pressed for time.” This statement reflects the breadth and depth of the review process. Also, the administrative commitment to the process was evident in the leadership provided and the devotion of time.

Needs Assessment

The primary goal of the program review was to determine the status of the graphic communications program. As a direct result, a variety of needs became evident. One immediate need was met with the hire

of two new faculty during the spring and summer of 1995. By September of that year, the new faculty were familiarized with the situation enough so that they could take up key roles in the second phase of the revitalization project: the needs assessment.

Many of the recommendations in the program review suggested that an expansion of the program was necessary in order to accommodate instruction related to a variety of printing processes and management-oriented content. The general consensus among the graphic communications faculty was it would be possible to offer both two- and four-year programs.

Thus, the decision was made to spend the following academic year reassessing the appropriateness of the AAS offering as well as examining the feasibility of adding a baccalaureate program. A formal needs assessment was deemed necessary to carefully determine whether there was a market for both curricula. Also, if a baccalaureate offering was pursued, advice would be needed on the direction of expansion—and how to plan well into the future for the development of such a program.

The course of action set forth by the Assistant Dean, as determined in conjunction with the graphic communications faculty, would be to complete the following six activities:

- a scan of internal institutional research, documents from the recent five-year period
- a literature search to determine the overall status of the industry,
- a review of respected programs with BS degrees in graphic communications,
- hold a second advisory board meeting for advice related to planning for the future,
- a survey of current students to determine:
 - satisfaction with current program, and
 - interest in starting a four-year program, and
- a survey of employers from surrounding states to determine needs for graduates of graphic communications programs

These six activities were considered the main components of the needs assessment and each area provided information that was useful in determining the

demand for a four-year graphic communications program in the Commonwealth of Pennsylvania. By December 1995, the first three components were completed and the survey materials were beginning to be drafted.

Review of Literature

The review of internal institutional research documents revealed that graduates of the Graphic Communications (GC) AAS program experienced positive placement ratings for the past five years, ranging from 85% to 100% annually. In addition, the GC placement rating exceeded the College total every year. For example, in 1992–93, the GC placement was 100% while the College total was 82%. Graduates also consistently rated job availability within the field as very good in follow-up studies.

Students who graduated in 1994 rated the Graphic Communications program using a four point Likert-type scale with descriptors including Very Good, Good, Poor, and Very Poor. Forty-six percent reported that the instructional quality had been very good while the remaining 54% rated it as good. Fifty-eight percent reported that the course content had been very good while the remaining 42% rated it as good. Equipment was rated as follows: 50% very good, 50% good. Overall there were very few poor ratings and the program mean rating for Graphic Communications was above the mean rating for all programs in the College.

The review of industry-based literature included annual reports of the industry from such organizations as the Graphic Arts Technical Foundation (GATF), the National Association of Printers and Lithographers (NAPL), and Printing Industries of America (PIA). The data included statistics to reveal that the printing industry ranks as the third largest employer in the United States and that employment increased by 27% from 1983–1993. The amount of factual information gleaned from these resources was tremendous, but can be summarized by stating that the industry is apparently growing at a steady pace.

Graphic communications programs at other institutions were of interest to the assessment process for a

variety of reasons. First, it would be futile to offer a program that was identical to other programs within the region, so regional competition for enrollment was a definite consideration. Although there are other graphic communications programs within the Commonwealth of Pennsylvania, they are typically part of a broader course of study in industrial technology or technology education. Pennsylvania College of Technology already offers a unique program in that it provides an in-depth focus on printing and publishing technologies. This specific curricular emphasis is supported with excellent new facilities dedicated to instruction and research in this body of knowledge as well as modern equipment that is standard in the printing industry. Also, by comparison to some of the recognized elite programs in the nation, Penn College has a much smaller student body thus boasting a relatively low student to instructor ratio in addition to significantly lower tuition costs. All these combined factors provided further reason to believe that there is a market within the mid-Atlantic region that would continue to support the current curriculum and even grow with a new baccalaureate degree program.

Further reason for interest in other highly respected programs was that, by March, 1996, the faculty had actually started into the third-phase of the project—curriculum revision for the AAS program. As such, the faculty were compelled to examine any recent trends occurring in curriculum development projects within the field. Program and course titles were also of great interest for the sake of identifying content with accurate and concise terminology.

Advisory Focus Group

On February 23, 1996, the second Advisory Board meeting occurred. This day-long session was organized as a focus group activity. The primary objective of this activity was to ask individuals with a great deal of industry experience very specific questions. The Director of the College Technology Transfer Center served as the facilitator of this session. After attending a number of meetings with the Assessment Committee, she began to learn more about the con-

tent area and the sort of information that was needed from the advisory group. As moderator she kept the group on task and monitored the use of time.

Transcripts from the meeting show that the morning session discussion focused on hardware and software issues and the need for college graduates with management skills. The outcome of the first topic was a consensus that Macintosh computers are still predominant within design circles and the printing and publishing industry although IBM compatible PCs had made significant inroads based on lower initial cost. The major software packages identified as essential to the educational process included QuarkXPress and/or Pagemaker for page layout, Illustrator, Freehand or Corel Draw for object-oriented graphics, and Photoshop for bitmap image manipulation. The advance of imposition software was also discussed with no specific recommendations made.

The second topic of the morning involved the need for graduates from management programs. The general response was that even though industry was reducing the number of middle managers, there would always be a need for people prepared with such skills. The reality is that most graduates will not start in managerial roles immediately anyway. Typically, recent college graduates will start in sales positions or in entry-level production positions where they are cross-trained in order to “learn the ropes.”

Following a tour of the facilities, the topic for discussion in the afternoon was the need for equipment and changes to the facilities. The majority agreed very quickly that four old horizontal graphic arts cameras should be removed but that four vertical cameras ought to remain for now. Most felt that stripping and imposition were so fundamental that a lab full of light tables should be kept at least another five years and then reassessed. The purchase of more scanners was recommended along with the integration of digital photography. The two computer labs were considered excellent and good, respectively.

In regard to teaching specific printing processes, the board suggested that offset lithography should remain predominant while flexography and non-impact systems should be considered as additional

viable offerings. Screen printing was also considered an option; however, a few board members felt it was not necessary. The group stressed that students should be able to generalize their experiences with different systems to the broader industry and be able to transition across systems and from old to new technology. Most agreed that color theory had transitioned from an advanced topic to a fundamental body of knowledge. In the area of general studies, the group felt students should be better prepared in mathematics, general sciences, speaking skills, and group dynamics. They also felt that the ability of printing and graphic design students to interact through shared courses was an asset to the program.

The final challenge posed to the panel was to suggest a name for the program. Two suggestions that arose were Graphic Imaging and Digital Printing and Publishing.

In summary, the Advisory Board provided detailed information related to the status of the industry within the region. They also assessed Penn College’s position to serve their needs related to human resource development. Of all the components of the needs assessment, the advisory focus group activity was perhaps the most rewarding in regard to the quality of information received—largely due to the participants.

Student Survey

Another key component of the needs assessment was a student survey. During the Fall term of 1995, 31 students in the two-year Graphic Communications program completed a survey designed to indicate their perspective on the needs of the program and potential interest in furthering their education in the field. For items related to past experiences, the survey used a four-point Likert-type scale with descriptors ranging from very satisfied, satisfied, somewhat satisfied, and not satisfied.

Overall, 80% of the students felt satisfied or very satisfied with the content of the program. Despite the fact that their two-year term was somewhat unsettled due to the transition of faculty, 63% were either satisfied or very satisfied, 37% were somewhat

satisfied, and 0% felt not satisfied with instruction. A few students added comments such as “some courses need to be more organized,” “instructors need to be permanent,” and “the program has had a lot of unsettlement with instructors since term began in 8/94.” Undoubtedly, this was a difficult period for the students.

When asked about equipment needs, the students were quick to identify problematic equipment: a film processor, some old graphic arts cameras, and several duplicators were cited, specifically. Yet they also focused on broader issues such as the need for “bindery equipment, screen printing equipment, and library materials.” Another student felt the program “could use a new multi-color press.” Overall, 53% of students were either satisfied or very satisfied, 30% were somewhat satisfied, and 17% felt not satisfied with the equipment that was available for their use.

Another item asked students what topics, knowledge, and experiences they felt would help meet their educational goals that they did not get as part of their associate degree program. The written responses included bindery, business courses, internship experience, screen printing, use of letterpress equipment, application of a vector-based graphics software program, and more diversity of printing processes.

The students expressed interest in pursuing a variety of related occupations upon completion of their program. Printing plant manager, press operator, and electronic page layout/prepress were the most popular choices. Other categories that were of significant interest to the students included scanner operator, sales/marketing, and owning their own business. Some interest was shown in screen printing, finishing and bindery, and education. Little interest was shown in platemaking, stripping, and camera operation. Most believed they would work in commercial offset establishments, in-plant printing departments, or specialized commercial printing companies. A significant number felt they might work in newspaper or book publishing operations.

When asked if, at any point in the future, they would like to enroll in a bachelor’s degree program in graphic communications, 77% of the students

responded “yes.” Of those, 70% identified Penn College as their preferred school.

Employer Survey

In March 1996, an employer survey was completed and mailed to nearly 1,000 businesses in graphic communications and closely-related fields throughout Pennsylvania and surrounding states. At this time, the College was seriously interested in learning whether a bachelor’s degree program was viable and this project served as a sort of market analysis. Unfortunately, the survey yielded a disappointing return rate, and was somewhat biased towards the background of the individual completing the form. Nevertheless, useful information was gleaned from the returned forms that provided some insight into the needs of industry and its expectations of college graduates.

A variety of establishments responded, including sheet-fed offset printers, screen printers, publishing houses, newspapers, business forms, quick printers, and many other related businesses such as platemaking services, digital printers, consultants, and a cartographer. As is typical in the printing industry, the vast majority of these businesses were non-unionized—only one reported being a union shop. As for company size, 87% of the responding companies employed 1–15 people, 5% employed 16–50 people, 3% employed 50–100 people, and 5% employed 100 or more people.

The response to whether there was a need for people with a college degree in graphic communications was positive—70% identified a need for workers prepared with an associate’s degree and 58% needed employees with a bachelor’s degree in graphic communications. When asked which level of graduate they would most likely hire for positions in their company, 47% of respondents felt there was an equal likelihood that they would hire someone with either an associate’s or a bachelor’s degree, 21% answered associate’s degree, 18% answered bachelor’s degree, and 14% would not require either.

The survey was also used to identify other information thought to be useful in the needs assessment.

An open-ended item asked respondents to describe what courses, subjects, or skills were essential to an associate's degree program. Some of the typical comments are listed below.

- computer knowledge and training, print theory and application, quality control
- technical knowledge, time management, production management
- prepress, digital imaging, proofing, press
- computer graphic design basics, printing basics, finishing and binding basics
- graphic design, traditional and digital prepress, offset lithography, bindery
- page composition, typography, software training, computer file management, effective use of color
- computer skills, camera work, including halftones, film assembly, press operation, bindery skills

A similar, open-ended question asked what additional courses, subjects, or skills should be included in a bachelor's degree program. Some of the typical comments for this item are listed below:

- more technical, communication, and business
- design, color separation, color printing, finishing, sales, business management
- dealing with customers, proper and effective customer service
- business courses
- business management, estimating
- advanced technology in computer design and applications, basic business courses
- computer systems technology—how they actually work
- troubleshooting files, advanced software, Postscript.
- Internet

In response to a list of specific skills, knowledge and abilities that students should develop, teamwork was ranked second only to offset lithographic printing process. Also, all categories related to training with specific software packages ranked surprisingly high. Other highly-rated categories included color theory, proofreading, bindery, and computer network administration.

One item was dedicated to the ongoing quest to find an appropriate title for the program and numerous suggestions were offered. The last item on the survey asked for any additional comments related to the needs of the graphic communications industry and a handful of very insightful comments were offered. These items are summarized below.

- The industry needs people with common sense who are willing to work hard.
- Today's students need a better work ethic and understanding of production and getting jobs out on time—regardless of any situation.
- Entry-level employees need to know more about how we do things rather than just what we do.
- With the growth of the Internet, the need for printed graphics may become problematic.

The feedback from the returned surveys was very useful and added the final positive reinforcement that was needed to proceed with proposing the establishment of a four-year degree program. In addition, employers provided numerous suggestions for program content and industry needs. They universally emphasized the need for computer skills, the ability to learn, hands-on experience, and a clear understanding of the production process.

The entire needs assessment process was very thorough and effective. As a result of the outcomes of the various components of the needs assessment, an executive-level decision was made to continue offering the associate's degree program and to proceed with a formal proposal for the establishment of a new four-year bachelor of science degree program in the field.

Curriculum Development

On September 28, 1995, the Assistant Dean of the Integrated Studies Division called a meeting of the Graphic Communications faculty primarily to plan for the needs assessment but also to review the AAS curriculum in place at that time. In anticipation of revising the two-year program, a "brainstorming" session was also planned to draft a revised curriculum for the AAS program. The latter activity proved

overwhelming and the decision was made that each faculty member would devise what became known as their individual “dream curriculum.” The so-called dream curricula were drafted and revisited several times during the next several months. Each member’s views gradually shifted and changed as a result of discussion, compromise, and discoveries made during the needs assessment process. By March, 1996, the individual visions had merged into one comprehensive product which prompted the faculty into the curriculum development stage for the AAS program. By May, 1996, the final piece of the needs assessment, the employer survey, was in place and administrative approval was given to proceed with a proposal for the BS program. The proposal had to be completed during the summer of 1996 to be ready for the formal proposal process which begins each year in September.

In early March, 1996, the “dream curricula” were revisited for the last time and consensus was reached as to the outline of the curriculum for the AAS program. One key decision was to reduce the total number of courses that dealt with film assembly and camera work from five courses to two. A new course was added to provide an introduction to the profession for incoming freshmen. A new digital imaging course would also be implemented. The traditional mechanical prep course would become half manual and half computer-based and color theory would become a fundamental course as opposed to an advanced course. An art course was added to help technical students understand design concepts and all other courses would undergo significant revisions.

By April, 1996, the faculty had revised the program objectives, identified the courses to be offered, planned for the scheduling of classes, reviewed the numbers of credits, and met with faculty in the Communication Arts Department to discuss changes to courses that were cross-over requirements for the different programs. Then, the shared workload of writing specific course curricula was split up among the faculty.

In preparation for writing the course curricula, the College Curriculum Development Manual was reviewed. Based on the College policy and format, a

standard layout was developed using a common word-processing software. In order to minimize formatting issues later, and to provide a clean, consistent package in the end, each faculty member used this layout in preparing their assigned courses.

Four-Year Program

In May, 1996, with approval given for pursuit of the bachelor’s degree program, the entire process was broadened to include the possible courses that would fit into that program. First, program objectives needed to be decided for the BS program. A few old courses from the AAS program, such as Estimating, Paper and Ink, and Advanced Typography, were revised to fit more appropriately into the four-year program. Then, new courses were identified. Many new courses were added to expose students to different printing technologies such as flexography, screen printing, and on-demand non-impact systems. Courses related to digital technologies such as local area network management, layout of web pages, and CD-ROM publishing were added. Other new courses were considered necessary to address professional needs such as industry trends and issues, and management-oriented content. Since some business courses were required in the program, it was also necessary to confer with the leaders of that College Division for recommendations and approval.

Once again, the workload for writing the curriculum was divided among the faculty—while the Assistant Dean took on the responsibility of organizing the introductory sections of the proposal. During the summer months, the faculty were remunerated for the time spent diligently identifying resource materials and writing the course syllabi. There were also a number of meetings scheduled throughout the summer to present drafts, review the work, and complete three more revisions. These meetings were also used to continue planning for the remodeling of facilities and the purchase of new equipment.

The selection of an appropriate program title was perhaps the most difficult decision to be made in the entire process of redeveloping the program. Due to

First Semester			Credits	Fifth Semester			Credits
PNP	110	Intro to Printing and Publishing Professions	2	PNP	350	Ink & Substrates	3
PNP	112	Optical Imaging for Film Intermediates	3	PNP	352	Printing Estimating	3
PNP	114	Electronic Typography	3	PNP	354	Trends & Issues in Printing & Publishing *	3
PNP	116	Film Assembly: Stripping and Imposition	3	CHM	100	Fundamentals of Chemistry	4
CSC	110	Intro to Information Technology	3	MTH	158	Elementary Statistics I or	
OFT	101	Keyboarding & Its Applications	1	MTH	160	Elementary Statistics with Computer Applications	<u>3/4</u>
FIT		Fitness & Lifetime Sports	<u>1</u>				16/17
			16				
Second Semester				Sixth Semester			
PNP	120	Page Layout & Design	3	PNP	360	Digital Imposition & Preflight	3
PNP	122	Digital Systems for Graphic Imaging	3	PNP		Program Elective	3
PNP	124	Offset Lithography	3	ENL	351	Document Design or	3
PNP	126	Process Color Theory & Application	3	HUM	301	Scientific Literature: History and Social Contexts	
ENL	111	English Composition I	<u>3</u>	PHO	101	Black & White Photograph	3
			15	SPC	101	Fundamentals of Speech or	3
Third Semester				SPC	201	Interpersonal Communication	
PNP	230	Color Reproduction	3	MGT	115	Principles of Management	<u>3</u>
PNP	232	Finishing & Distribution	3				18
PNP	234	Advanced Offset Lithography	3	Seventh Semester			
ENL	121	English Composition II or	3	PNP	470	Printing Production Management	3
ENL	201	Technical/Professional Communication		PNP	472	Publication & Transmission of Digital Media	3
MTH	180	College Algebra & Trigonometry I	<u>3</u>	HIS	262	Technology & Society **	3
			15	ENL	121	English Composition II or	3
Fourth Semester				MGT	248	Supervision and Human Relations	3
PNP	242	Production Printing	2	MGT	360	Legal environment of Business	3
PNP	244	Advanced Electronic Typography	3			Elective-Humanities or	
PNP		Program Elective	3			Social Sciences ***	<u>3</u>
ART	255	Intro to Computer Graphics	3				18
PHS	103	Physics Survey	3	Eighth Semester			
		Elective-Humanities or /Social Sciences or Art	<u>3</u>	PNP	495	Capstone	2
			17	MGT	330	Managerial Decision Making	3
PNP	355	Internship: To be completed during one Summer semester.				Elective-Humanities or	
						Social Sciences	3
				FIT		Fitness & Lifetime Sports	1
						Open Elective	3
						Open Elective	<u>3</u>
							16

Figure 2. New curriculum sequence for Bachelor of Science in Printing and Publishing Technology at Pennsylvania College of Technology

the immediate impact of a title, it would have to be direct and reflect the correct image. At Penn College, the program title "Graphic Communications" was often confused with the title "Graphic Design," another program area within the Department of Communication Arts. The faculty agreed that "Printing Management" would be an appropriate title for the four-year program. However there were internal political issues concerning the use of the word management and the Assistant Dean suggested that, for the sake of expedition, this issue was best avoided. With hopes of trying to accurately identify what this program offered, the final decision was to call the AAS program "Printing and Publishing Production" and the proposed BS program "Printing and Publishing Technology."

Upon completion of the revisions and a final decision regarding the program title, the proposed courses needed to be assigned official course numbers by administrative personnel. Once this was done, the proposal was submitted for the formal review process.

On August 23, 1996, the first official draft was done. It was presented for review by the Integrated Studies Division faculty and was accepted with minor revisions. Within a month the proposal came before the College Curriculum Review Committee. The graphic communications faculty met before this Committee to answer questions and clarify any points that were unclear. Although the Curriculum Review Committee identified some flaws, they accepted the proposed curriculum pending minor revisions and congratulated the faculty and Assistant Dean on doing fine work on such a large curriculum project. The final draft was submitted for approval at the executive-level a few weeks later and with final approval on November 1, 1996, the curriculum development aspect was completed.

Facility Planning and Equipment Acquisition

Obviously, there still remained work to be done in regard to facilities development and the acquisition of equipment to support the new program. Most of

these details were carefully planned and specified in the curriculum proposal. Progress in developing the facilities actually began even before the final approval of the BS program since the revised AAS program and related graphic design programs would require certain improvements. During the Fall of 1995, one computer lab was completely refurbished and equipped with 20 new PowerMac 9500 computers with 21" monitors and computer overhead display capabilities. A room connected to this lab was equipped with a new Linotype-Hell Topaz high-end flatbed scanner as well as a new ScanMate 3000 baby-drum scanner and two Tectronix digital color proofing printers. Also through Linotype-Hell, a new Quasar drum-type imagesetter (reported to be the second installed in Pennsylvania) with a raster image processor (RIP) and new film processor were installed in what is now referred to as "the output room," which also houses a Linotronic 330 imagesetter and accompanying RIP.

A commitment was also made, during the Fall of 1995, to renovate the traditional film imaging laboratory by removing the horizontal cameras and redesigning the space. Plans were immediately drawn that involved the removal of several darkroom walls to open space for a classroom and major screen printing equipment. This multipurpose space can now be used for lectures and is completely equipped for high quality screen printing and/or traditional film imaging using vertical cameras in the remaining three darkrooms. Also, a donated Agfa Rapiline 660 processor replaced an obsolete lith processor and another adjacent darkroom was opened to extend an existing color proofing lab. This color proofing addition is now equipped with a new exposure unit and Matchprint color proofing system which complements the existing Chromalin, Color Key, and Chromachek proofing technologies available to students. Work began on these projects during the Spring and was completed during the Summer of 1996 thanks to the efforts of a very capable General Services staff.

Currently, work is under way to renovate the offset press area to best utilize the available space and increase the number of presses and duplicators available for student use. A new two-color large format



Figure 3. Student using new Quasar imagesetter in "the output room."

offset press is being purchased and installed. Also, a space once used for fine-art photography is being renovated to develop an entirely new flexography lab. A new 7" inline four-color flexography press is being installed along with peripheral platemaking and plate mounting equipment. Space is available for a second small-format flexo press and long-range plans recognize this need.

Over a dozen new low-end flatbed scanners have been purchased and connected to computers at strategic locations throughout the prepress facilities. A file server has also been dedicated to the program to support lab management and the routing of digital information. A second computer lab is also scheduled to be re-equipped within the next year in order to continually upgrade the prepress facilities. The conversion of this lab, which was networked with localtalk, will finally complete the networking of the entire wing with high-speed Ethernet. The older computers have been dispersed throughout the program to serve for less-demanding applications.

For the immediate five-year plan, the College has made a significant budgetary commitment to the revitalization project. It recognizes that although this

is an expensive program, the facilities, equipment and staff also support the graphic design components of the Department. In addition, the College in-plant printing operation shares some of the equipment which reduces outsourcing of printed materials for the institution. When the extended use and purpose are factored in, the expenditures seem less overwhelming.

Summary

During the 1994–95 academic year, the Graphic Communications program functioned as the Integrated Studies Division's pilot for the then-new process of program review at the Pennsylvania College of Technology. That process involved students, faculty, key administrators, in-plant production staff, and an advisory committee. A result was the recommendation to revise the program to bring it closer in line with industry, including more experience with digital technologies and more start-to-finish projects. The recommendations also spoke to equipment needs, most of which were tied to conceivable changes in the curriculum.

The needs assessment process took seven months to complete and consisted of six key activities: a scan of internal documents, a major literature search, a review of other programs, an advisory board meeting, a survey of students, and a market survey of potential employers. The conclusion was that offering a four-year program in printing and publishing would be a viable venture.

The curriculum development process began with the revision of the AAS program. This revised program provides an overview of all printing technologies and examines the fundamentals of the printing process. Students relate this knowledge primarily to offset lithographic technology (where most jobs are in industry) thus providing some depth to the program. Through practical lab experiences, students develop skills related to pre-press and press work as well as a variety of finishing processes. There is also an opportunity to explore other printing technologies through electives.

The BS program includes courses that explore other printing processes, management-oriented content and experiences related to digital technologies such as hypertext media, CD-ROM publishing, and managing networked systems. Functioning as a progressive professional program, the baccalaureate provides two additional years for focus on other processes, providing breadth, and prepares students for entry-level positions in production, sales, training, and management. The ability to integrate

management courses improves the marketability of graduates and puts a Business Management minor well within reach.

The equipment and facilities are generally the selling points of the program when prospects visit the campus. The program area is a true production facility which also functions very well for instructional purposes. Few regional programs can boast the facilities and level of equipment support available to students studying printing and publishing technology. A five-year plan for updating facilities and equipment is kept current and promises to support the program as related technologies continue to emerge.

The entire three-year project was the result of significant teamwork on behalf of the Department of Communication Arts faculty, and the outstanding leadership provided by the administrators of the Integrated Studies Division. A tremendous amount of planning and effort went into the revitalization of the traditional graphic communications program at the Pennsylvania College of Technology and a vast number of resources were utilized.

Author's Note

This article is dedicated to the memory of Mr. Harold Newton, and with regards to Mr. Fred Schaeffer. Both were past faculty of the Penn College Graphic Communications program.

Factors Affecting Dot Gain On Sheet-Fed Offset Presses

by Yung-Cheng Hsieh

Printing is the process of manufacturing visual products that are aimed to communicate messages through permanent graphic images and has been identified as the single most significant technological development in the history of human beings. The foundation and power of a printing process is the ability to communicate information exactly to any number of people at the same time and reproduce high-quality images in large quantities at a reasonable cost. The growth of the printing industry has been immense. Hird (1995) noted:

The printing industry is constantly developing more efficient ways to meet the needs of our growing population. Industry has made numerous and significant breakthroughs in technology. The printing industry is now one of the largest service organizations in the world. Its sales incomes and number of employees rank it as the sixth largest industry in the United States. (p. 10)

This paper is concerned primarily with offset lithography, especially sheet-fed offset lithography. Offset lithographic printing is the most widely used printing process in the commercial printing industry. Offset lithography is used to produce over 70% of all commercially printed products. The purpose of this paper was to investigate the dot gain phenomenon on sheet-fed offset lithography by providing an overview of offset lithography, describing what dot gain is and how and when it occurs during the offset printing process, list the factors that affect dot gain, and explain how these factors influence the percentage of dot gain in offset lithography.

Overview of Offset Lithography

Offset lithography is a process utilizing flat surfaces to transfer images. The basic principle behind offset printing is that “water and oil do not mix.” An image is processed on a “plate” surface by depositing a water-repelling coating in the pattern of the image to be reproduced. This coating, in turn, enables oil-based ink to adhere to it. The non-image surface of the plate accepts moisture, thus repelling the ink.

The typical offset printing press includes a group of three primary cylinders. A flat metallic plate is wrapped around a plate cylinder and ink and water are applied to this plate from separate systems. The ink that adheres to the image area will be transferred to another cylinder called the blanket, and then the blanket, in turn, will transfer the image to the substrate (see Figure 1). The surfaces of these three

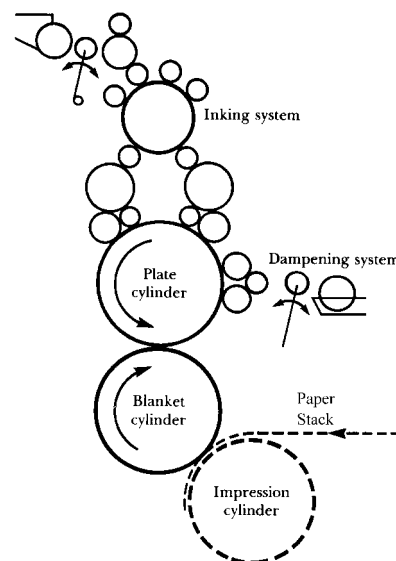


Figure 1. Typical offset lithographic process (Dejidas & Destree, 1995, p. 6)

cylinders must travel at the same speed (the same distance during each cylinder revolution). They must be adjusted for minimum cylinder-to-cylinder squeeze capable of producing accurate printed reproduction and long plate life (Hird, 1995).

Overview of Dot Gain

In graphic arts, dot gain (from film to paper) is the difference between the dot area of the film and the dot area of the proof or printed sheet. Due to both technical reasons and the effect of light entrapment, printing without dot gain is impossible. It has been recognized that dot gain is one of the most critical factors associated with printing quality in the lithographic process. For many years, it has been one of the most important measured values for quality improvement and standardization in printing.

What is Total Dot Gain?

Total dot gain, which refers to the sum of both physical (also called mechanical) and optical dot gain, is the difference between the dot area on the film, as measured with a transmission densitometer, and the dot area on the printed sheet, as measured with a reflection densitometer (GATF Staff, 1995). Jackson (1990) defined physical dot gain as the total physical increase in halftone dot size that occurs at each image transfer stage between film separations and printed press sheets. It can occur during color separation, film contacting and platemaking, and on press when ink is printed on paper.

Killeen (1995) explained that optical dot gain is a visual phenomenon created because of the light-absorbing characteristics of ink and the light-scattering characteristics of the substrate. When light hits the non-image area, or "white space," it is scattered and some of the light is absorbed below the halftone dots. This light cannot be reflected back to the eye and is said to be "absorbed." Dots appear darker and larger than their actual density and size due to the scattered light being absorbed by the ink and paper. It is important to note that the dot sizes are not physically changed, but they appear as if dot gain has

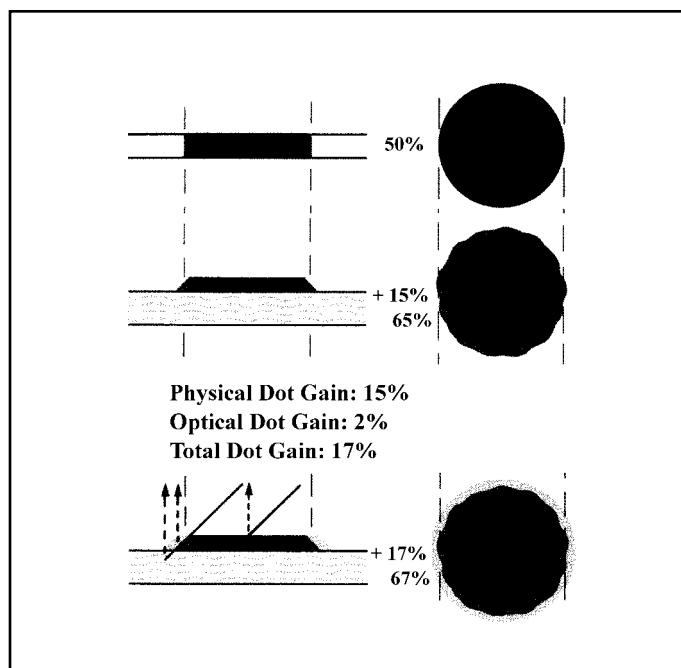


Figure 2. Total dot gain is a combination of the physical increase and the optical increase in dot size.

occurred. A graphic explanation of total dot gain is shown in Figure 2. As shown in the figure, the physical dot gain is 15% and the optical dot gain is 2%; therefore, the total dot gain is 17%.

Why is Dot Gain So Critical?

Most of printing defects in the offset lithography are either the results of poor operating skills, the use of defective materials, and/or improper techniques or control. They are usually correctable. Dot gain, on other hand, is a characteristic defect of offset lithography and also a built-in integral part of the offset lithographic printing process (Bruno, 1986).

Dot gain can cause an overall loss of definition and detail, color changes, and problems with contrast, ink hues, ink density, and trapping (Killeen, 1995). Uncontrolled dot gain is ultimately to blame for much of the waste in offset lithography. For example, if the dot grows more than it should, the color on the print would be darker and the desired color will not be obtained. This type of problem, color variation, is probably the largest single problem in offset lithography. Dot gain has the greatest influence on color variation, so the benefits of understanding, controlling, and compensating for dot gain are obvious (Dot gain: Causes and cures, 1982).

Measuring and Controlling Dot Gain

For many years, offset lithographic printers have been well aware of the factors contributing to dot gain. In fact, the formulas for measuring dot gain have been available for almost sixty years through the studies done at Eastman Kodak (Murray, 1936). Printers believe that dot gain must be predicted and simulated when making press or off-press proofs to match press units.

It is obvious that uncontrolled dot size change will seriously distort tone and color reproduction. Better control of dot size change means better control of color. Better control of color will reduce rework and scrap, and thus lower costs and increase productivity. Therefore, it is necessary to monitor the dot gain on press closely, establish a standard that will match the chosen proofing system, and then maintain that standard in the pressroom (Prince, 1994). M. Southworth and D. Southworth (1989) stated:

Since dot gain variation has the greatest influence on color variation, it is important to understand how to control and compensate for it. If controlled, dot gain is not necessarily bad—which is just as well, because dot gain is inherent to every printing process. (P. 13, chap. 14).

Thus, dot gain variation must be measured and controlled. Even though dot gain cannot be eliminated, its effect can be compensated for and minimized.

Densitometers

A densitometer can measure dot area, density, trap, hue error, grayness, and printed contrast of either black-and-white or colored areas on transparent or opaque materials (GATF Staff, 1995). Brehm (1992) defined densitometers as instruments that are designed to determine, indirectly, the light absorbed by a surface. Brehm also indicated that there are two kinds of densitometers: transmission and reflection.

Transmission densitometers measure the amount of light that is transmitted through a transparent material such as a film base.

Reflection densitometers measure the amount of light reflected from a print and are a critical aid in quality control for all involved in the printing production process.

In printing and publishing, densitometers have been used extensively in prepress and pressroom operations. Esler (1989) further explained that the printing industry's growing preoccupation with statistical process control (SPC) requires reliable color-reading densitometers; these are now plugged into personal computers running elaborate programs for interpreting and reporting data gathered. According to GATF Staff (1995), the applications of densitometers include the following:

- monitoring tone reproduction in the production of halftones,
- calibrating and linearizing exposure devices such as imagesetters,
- determining dot sizes and tone values when inspecting film,
- measuring solid ink density (SID) on the printed sheet to assure that target levels of ink density are achieved,
- determining dot gain, print contrast, and trapping on a press sheet,
- comparing a press sheet to a proof, or comparing a proof to an original photograph, and
- collecting density and dot gain data to provide, and information about process stability and capability.

The densitometer, one of the most widely used instruments to measure dot areas, provides important information that helps to control and improve the printing process (GATF Staff, 1995). Generally, dot gain is measured from solid and tint values by densitometers. A densitometer can measure either incident light reflected from a substrate (reflection density) or light transmitted through a film (transmission density), or both (Killeen, 1995). Most modern densitometers use the Murray-Davies and/or Yule-Nielson equations to calculate dot gain.

Murray-Davies (M-D) Equation

In 1936, Alexander Murray of Eastman Kodak expressed the relationship between reflection density of halftone prints and dot area (Murray, 1936). Murray's study is the origin of the Murray-Davies equation. The Murray-Davies equation calculates both the mechanical and optical aspects of dot gain. Comparing the values for a printed dot area (with a reflection densitometer) with the values measured on the corresponding film (with a transmission densitometer) gives a figure for dot gain. This Murray-Davies equation has been accepted as the standard for calculating apparent total dot gain (both physical and optical). The Murray-Davies (M-D) equation is listed as follows:

$$\% \text{ apparent dot area (both physical and optical dot)} = 100 \times (1 - 10^{-(D(t) - D(p))}) / (1 - 10^{-(D(s) - D(p))})$$

where (using the appropriate filter for the colorant being measured)

D(s) is density of the solid;

D(t) is density of the tint;

D(p) is density of the paper/substrate.

(ANSI/CGATS.4-1993, 1993, p. 7)

Yule-Nielsen (Y-N) Equation

The Yule-Nielsen equation is a modification of the Murray-Davies equation used to estimate the physical dot area. It includes an "n factor" for paper which varies according to the type of paper, ink, and screen ruling used and yields a result which expresses only physical dot area (Yule and Neilsen, 1951). This Yule-Nielsen modification removes the light-scattering effect (optical effect), giving the physical dot area measurement and optical dot gain measurements separately. Accordingly, the formula will produce dot measurements significantly lower than those obtained with the Murray-Davies equation.

The Committee for Graphic Arts Technologies Standards (ANSI/CGATS.4-1993) stated that:

An empirically determined factor "n" is included to calculate an approximation of physical dot area resulting from the use

of specific raw materials (ink, paper, substrate, etc.) used in the printing process. (p. 7)

The Yule-Nielsen equation is listed as follows: (ANSI/CGATS.4-1993, 1993):

% estimated physical dot area =

$$100 \times (1 - 10^{-(D(t) - D(p))}) / (1 - 10^{-(D(s) - D(p))})$$

where (using appropriate filter for the colorant being measured)

D(s) is density of the solid;

D(t) is density of the tint;

D(p) is density of the paper/substrate;

"n" is an empirically determined factor, by trial and error, that must be determined for each set of raw materials. (p. 7)

It is important to note that the Y-N equation reverts to the M-D equation when the value of n in the equation equals 1.0. In the 1980s, several studies were conducted to determine an optimum value for the "n" factor. Pearson (1980) recommended:

...the choice of an n value between 1.4 and 1.8 can result in improved accuracy of dot area calculations for most practical conditions and is feasible for those cases where a background of experience and data with other values does not already exist. For practical reasons a specific value of 1.7 is recommended. (p. 415)

There are other methods of measuring dot gain, such as the Neugebauer Equations and System Brunner, but they are not as widely accepted as M-D and Y-N equations by the printing industry in the United States.

What Should the Dot Gain Values Be?

A unique aspect of dot gain is that the gain is not the same across the scale of halftone values; the gain is generally greatest around the 50% dots, tapering off at the highlight and shadow ends of the tone scale (Rinehart, 1983). Currently, there are no published standards of dot gain percentage for sheet-fed offset printing. Most sheet-fed offset printers in

	Black	Cyan	Magenta	Yellow
Sheet-fed, Offset	22%	20%	20%	18%
Web-Offset, Magazine	24%	22%	22%	20%
Non-Heatset Web, Newspaper	34%	33%	30%	28%

Values are Status-T, calculated using Murray-Davies Equation measured at 50% film tint.

Table 1. Typical dot gain values for three common printing conditions (X-rite, 1994, p.3).

the United States adopt the following four specifications to monitor their printing processes.

Recommended Specifications from Densitometer Manufacturers

In the pressroom, measuring dot gain at the 50% tint for each color is a quick evaluation of tone reproduction quality. Table 1 shows typical dot gain values for three common printing conditions calculated by densitometers that employ the Murray-Davies equation to measure at a 50% film tint with Status-T density responses.

SWOP Recommended Specifications

The 1993 version of Specifications for Web Offset Publications (SWOP, 1993) stated:

To more accurately control press proofing, it is recommended that total dot gain (physical and optical) from film to print should be 22%, plus or minus 4%, with no more than 4% difference among the four colors for sheetfed offset printing. (p. 156)

These dot gain specifications were based on the measurement and calculations done with a densito-

Color	Target Value	Tolerance
Yellow	18%	15-21%
Magenta	20%	17-23%
Cyan	20%	17-23%
Black (for pre-press proofs)	22%	19-25%

Table 2. SWOP dot gain specifications (SWOP, 1993, p. 13)

meter utilizing the Murray-Davies Equation and wide-band filter for apparent dot size, which incorporates both physical and optical gain. This total dot gain was measured in the 133-line screen, 50% dot area for black ink. No distinction was made between positive and negative plates and coated and uncoated papers. The dot gain specifications for the four process colors are displayed in Table 2.

FIPP Recommended Specifications

It has been recognized that dot gain values are different for positive and negative platemaking and are also affected by the use of coated or uncoated paper. For this reason four different specifications were recommended by FIPP (International Federation of the Periodical Press), a European research institute (Schläepfer, 1988). Table 3 displays the European scale based on the 50% dot measurement.

GCA Recommended Specifications

According to the GCA (Graphic Communications Association) Print Properties Committee 1984 Press Test Results (Strashun, 1985), the normal operating range of total dot gain for web offset, heatset publication presses printing on #5 coated groundwood stock is 22%, plus or minus 4%. This dot gain specification was based on the data read from the GATF (Graphic Arts Technical Foundation) 120-line 40% square-dot target by a Status-T densitometer employing the Murray-Davies equation.

Factors Affecting Dot Gain

To provide optimum reproduction quality, it is necessary to identify and understand the important causes of changes in dot area and reduce their effects as much as possible within the economic constraints of the offset printing process. Many studies have been made of the mechanisms of both optical and physical dot gain and the factors contributing to them.

Prepress Factors and Dot Gain

Killeen (1995) described the prepress factors that can contribute to dot gain range from such basics as the shape of the dot and the fineness/coarseness of the screen ruling through the method of making the halftones and negatives to plate exposure and processing.

Dot Shape

Generally, dots could be round, square, elliptical, or other special shapes. Dot shape is an important factor in tonal reproduction. Shape distortion during ink transfer from plate to blanket and blanket to substrate causes poor color and a shift in gray balance (Killeen, 1995).

According to Killeen (1995), the effect of dot shape on dot gain was explained as follows:

As the dot size approaches 50%,... the simultaneous connection of all four dot

	Positive plate	Negative plate
Coated Paper	19% ± 2%	26% ± 2%
Uncoated Paper	25% ± 2%	32% ± 2%
* It is assumed that the production run has to match the proof of print.		

Table 3. FIPP dot gain specifications at the 50% tint * (Schläepfer, 1988)

corners of square dots produces a sudden change in contrast called “tone jump”.... The elliptical dot (known as a diamond) was developed to avoid tone jump. Because of its elliptical shape, only two corners join at one time, resulting in smoother tone gradation.... To reduce dot gain, some printers prefer round dots because the round shape maximizes the area enclosed while minimizing the perimeter. (p. 30)

Screen Rulings

Screen rulings are described in lines per inch (lpi) and refer to the number of halftone dots per linear inch in the halftone or color separation. As a general guide, dot gain is less with a lower screen ruling (Killeen, 1995). The results of the North American Print Survey conducted by Muirhead, Burgstein, and Fahr (1985) indicated that dot gain measurements vary proportionally with screen ruling, decreasing as the ruling becomes more coarse. A 65-line screen has almost no dot gain, while a 150-line screen has considerable dot gain (Gretag Imaging, 1996). Gretag Imaging Company (1996) also indicated that it would be questionable to increase the screen ruling to more than 150, because in most cases it would cause extreme dot gain.

Conventional Screening Versus Stochastic Screening

The major difference between conventionally screened dots and stochastically screened dots is that stochastically screened dots are randomly spaced and clustered within the matrices and do not form coherent areas like conventionally screened dots (Stanton & Warner, 1994). The stochastic halftone screening process eliminates the need for halftone screen angles by relying on the placement of randomly controlled spots of color. Killeen (1995) indicated that some benefits of stochastic screening include no visible dot patterns, no moiré patterns, and no tone jump. However, according to the results

of an experiment conducted by GATF to compare the reproduction characteristics of stochastic screens with those of conventional halftone dots (Stanton & Warner, 1994), the stochastic screening process exhibited far greater levels of dot gain than the conventional halftone process for every ink color.

Negative Versus Positive Plates

It is a well-known fact that exposing a negative film on a negative working plate will cause dot gain. Tolley (1989) noted:

With negative plates, as exposure increases so does dot gain. Reducing exposure will shorten run length capacity. In other words: short run—lower exposure—less dot gain; long run—increase exposure—more dot gain. Typical dot gain on a negative plate is at least five percent on a 50% dot.... When a positive film is exposed to a positive plate, it works in the opposite way to the negative version. (pp. 45-46)

Table 4 compares the dot gain values between positive and negative printing based on the findings of North American Print Survey (Muirhead, Burgstein, and Fahr, 1985).

It is important to note that although negative printing exhibits more dot gain than positive printing, it is quicker and cheaper to produce negative film. Extreme care must be given during the plate exposure. Internationally accepted exposure control devices, such as the UGRA Plate Control Wedge, GATF Dot Gain Scale-II© for Midtone Control, FOGRA Precision Measuring Strips I and II, and System Brunner can be employed to determine the proper exposure control targets and assure the consistency of the platemaking process (Southworth & Southworth, 1989).

Press Factors and Dot Gain

Press factors such as press speed, fountain solution, blanket, and rollers all contribute to dot gain (Kil-

	Negative Process (%)	Positive Process (%)
Sheet-fed Offset		
All Proofs	18.6	17.2
SWOP Proofs	19.0	16.6
Production	20.2	17.2
Web Offset		
Commercial	24.7	19.3
Publication	26.8	18.6
* Based on 150 line-per-inch elliptical screen ruling.		

Table 4. Midtone dot gain* average by negative and positive plates.

leen, 1995). It is also generally accepted by printers that web presses produce more dot gain than sheet-fed press.

Press Speed

According to Bruno (1986), the faster the press runs, the sharper the printing, and the lower and more consistent the dot gain. Press speed is, therefore, another variable that should be controlled and factored into the proof equation.

Types of Blankets

Generally, there are two types of offset blankets in regular use: conventional (non-compressible) and compressible. Ferris (1996) remarked that compressible blankets are more popular today than conventional ones because they feature an additional rubber layer that functions similar to a shock absorber, allowing a blanket to rebound after it has taken a hit. Bruno (1986) further explained that:

On conventional blankets the deformation, especially in the nip, can cause

slippage of the blanket particularly on coated paper in dot areas from middle-tones to solids, resulting in directional distortion of the dot gain called slurring... Compressible blankets, on the other hand, compress under impression and do not exhibit the accumulation of rubber in the nip even under moderately excessive impression pressure. Therefore, compressible blankets are more tolerant to pressure changes, do not distort image elements, and maintain more consistent dot gain and dot shapes during printing (pp. 93-94).

Impression Pressure

Printing on a single-color sheet-fed offset press is accomplished by a three-cylinder unit which consists of a plate cylinder, blanket cylinder, and impression cylinder (see Figure 1). The cylinders must be brought together under pressure in order to transfer the ink and they must be released to stop printing (DeJidas & Destree, 1995). However, the relationship

between impression pressures and dot gain is far more complex than the generally accepted statement by printers: the higher the impression pressure or squeeze between plate and blanket and blanket and paper, the more ink will spread and the higher the dot gain. Lloyd P. DeJidas (1992), the Director of Graphic Services for the Graphic Arts Technical Foundation (GATF), indicated that impression pressure-related problems exist in various degrees in just about every offset plant and they are a major source of inconsistent printing quality in lithography.

Several studies have been conducted to investigate the relationship between plate-to-blanket pressure and dot gain and blanket-to-paper pressure and dot gain independently, but not simultaneously. It is important to study the relationship between the two pressures simultaneously because the effects of the two impression pressures partly counteract each other and usually cannot be regulated separately; printers should seek whatever combination seems to produce the best compromise between subjective and measured print quality (Lindqvist, Pauku, & Perilä, 1976). Further, due to the complex nature of the offset printing process, most process variables influence the quality factors contradictorily; that is, a given change in the two pressures might improve some print properties but make other worse. Therefore, the optimum impression pressures vary from case to case.

Bruno (1986) suggested that in order to insure overall contact of the plate, blanket, and impression cylinders, a squeeze of at least 0.003 inch (0.076 cm) must be used. This is equivalent to an impression band of about 3/16 inch (4.8 cm), which amounts to an impression pressure of about 50 pounds per lineal inch (8.9 Kg/cm) or about 200 pounds per square inch (0.36 Kg/cm²).

Fountain Solution pH

The fountain solution system on a sheet-fed offset lithographic press provides a water-based fountain (or dampening) solution to the printing plate before it is inked. Its major objective is to provide fast and complete separation of the image and non-image

areas of the plate; i.e., to prevent ink from becoming deposited on non-image areas (DeJidas & Destree, 1990). High-quality lithography depends on fountain solutions formulated to a precise level of acidity, and this level is bracketed by a narrow range on the pH scale (The Solution, 1985). It is fundamental that the fountain solution and printing ink are in balance to achieve high quality prints at maximum production levels. The pH of fountain solutions is one of the major factors to consider in reaching a balance between ink and fountain solutions (Brothers, 1988).

The lower the pH, the more acidic the solution; conversely, solutions with a pH higher than seven are alkaline. DeJidas and Destree (1990), GATF Production Director and GATF Editor in Chief, explained the effects of fountain solution pH on the offset printing quality:

Insufficient acid in the dampening solution lessens the gum's ability to adhere to the plate. Eventually, ink starts to replace the gum in non-image areas. This is called plate scumming... Excessive acid also causes plate blinding, the loss of ink receptivity in the image area. The extra acid attacks the plate in the image areas, causing the image to deteriorate.... Another problem associated with excessive acid in the dampening solution is roller striping and poor drying of ink. (p. 5)

Gerson (1987) indicated that the generally recommended fountain solution pH is 3.5 to 4.0 for web offset printing; for sheet-fed printing, the recommended range is 4.0 to 4.5.

Ink Film Thickness

Control of the amount of ink applied to the printing substrate (ink film thickness) is one of the most important factors for success in offset lithography. Theoretically, the thicker the ink film, the more saturated the color. In practice, however, a point is reached beyond which spaces between halftone dots begin to fill in because of excess ink,

and light colors begin to look “dirty” (Measuring Ink Density, 1986). Control of ink film thickness is usually based on measurements made with a reflection densitometer and/or an ink film thickness gauge.

A study conducted by Takahashi, Fujita, and Sakata (1983) at Tokai University in Japan concluded that the more ink supplied, the thicker the ink film, and therefore, the greater the dot gain. In fact, Johnson (1980) reported that dot gain increases as the square of the ink film thickness. Furthermore, Scarlett (1989) suggested that on the subject of ink and water, ink should be carried at the thinnest film possible conducive to achieve good runnability, and water, in turn, should be kept to the minimum required to keep the plate clean.

Ink and Dot Gain

The effect of ink rheology on offset printing quality is a complex subject. One of the key issues is the effect that ink has on dot gain. Many elements of ink, such as pigment, viscosity, tack, stability, and strength, contribute to overall dot gain (Killeen, 1995).

Strength

Strength is an indication of the amount of pigment contained in an ink (Scarlett, 1988). Due to the high cost of ink pigment, it is easy to reduce cost by reducing the amount of pigment. According to Killeen (1995), reducing the pigment reduces the strength of the ink, causing the press operator to run a thicker ink film, which can cause dot gain problems on press. However, an optimum level of strength should be determined by experimentation, which varies from case to case.

Tack

Tack is the stickiness of an ink (Southworth & Southworth, 1989). Scarlett (1989) indicated that the higher the ink tack, the lower the dot gain.

Scarlett (1988) went further to explain that if tack is too high, the ink will pick up the paper; if it is too low, the ink will not print a sharp dot. Scarlett also indicated that the normal rule of thumb for sharp printing is to use the highest tack possible within the limitations imposed by the paper and press speed.

Viscosity

Ink viscosity is different from ink tack. Viscosity is a property of fluids resulting from molecular attraction which makes them offer a resistance to flow (Southworth & Southworth, 1989). Ink viscosity is affected by ink temperature. According to Killeen (1995), if the press is cold, the viscosity of the ink will be higher and the dot gain lower; if the press is too warm, the viscosity will be lower and dot gain higher.

Water Pick-Up

In offset lithographic printing, a delicate ink-water balance is essential for printing quality. It is not completely true to state that the lithographic process is based on the fact that ink and water do not mix. In fact, Southworth and Southworth (1989) indicated that inks do absorb some water, normally at the 30–40 percent level, but this should level out when they reach their limit. The water pick-up of an ink will reduce the viscosity and tack of the ink, which, in turn, creates dot gain problems.

Paper and Dot Gain

Generally, there are two major categories of paper types: uncoated, which includes newsprint, some magazine papers, bond, and most book paper; and coated, which includes most magazine papers and high finish and glossy papers (Bruno, 1986). Printers can rely on assistance from their suppliers in making selections of both coated and uncoated stocks. The printability of each of the paper types is determined by its surface properties such as acceptability of ink transfer and amount of absorption.

Absorbency

Absorbency is the property that determines at what rate and in what amount the ink penetrates the paper. Killeen (1995) stated:

The more absorbent the paper, the higher the dot gain percentages will be.... The rate of absorption plays a key role in the amount of dot gain on press. When ink is set on an absorbent paper, it will penetrate the paper and spread. (p. 35)

An experiment conducted by MacPhee and Lind (1991) found that uncoated papers have a rough surface that absorbs and lets the ink spread, and therefore, produce greater dot gain than coated paper.

Smoothness

The surface of uncoated papers is filled with much irregularity, intertwined cellulose fibers that create peaks and valleys (Adams, Faux, & Rieber, 1996). To smooth out the surface irregularity of uncoated paper, it is ideal to coat the paper surface with a clay-like material to create coated paper. Since coated papers have less surface deviations from an ideal plane than do uncoated papers, the differences in ink acceptance and absorptivity from point to point in the surface of coated papers are less than those of uncoated papers. Therefore, coated papers tend to improve the fidelity of halftone reproductions because they are normally less absorbent and smoother than uncoated papers (Bruno, 1986). Southworth and Southworth (1989) noted that smoothness of a paper is usually visually examined before and after drying.

Summary

The literature related to dot gain issues in offset lithographic printing was reported, including the types of dot gain, the importance of dot gain, how to measure and control it, and the factors affecting it.

Highlights of previous research on dot gain were also presented with implications for controlling and improving printing quality.

Previous studies suggested that, due to the complex nature of the sheet-fed offset lithographic process and rapidly changing technology in this industry, dot gain can still cause problems in printing quality, although advanced electronic prepress systems and sophisticated densitometry have brought some measure of control to the problem of dot gain. It is important to remember that dot gain is an inherent part of the offset lithographic printing process. Setting up optimum process operating conditions requires experience and experimentation.

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Assessment of Quality and Productivity Improvements in the Printing Industry Using the Baldrige Quality Criteria

by Eugenio Lord

Quality and productivity improvements are central to any printing organization trying to survive, compete, and make a profit in an increasingly competitive environment. Productivity is crucial because it is one indicator of organizational effectiveness. Quality is vital because it is demanded by customers who are growing more and more sophisticated each year. The teachings of “quality gurus” Deming, Juran, and Crosby have provided the foundation for organizations to move towards quality and productivity improvement. According to Neves et. al. (1994) the concept of quality and its implementation in organizations have been greatly influenced by the debut of the Malcom Baldrige National Quality Award.

Need for the Study

In a nation-wide survey sponsored by American Printer and DuPont Printing and Publishing with a sample of 296 commercial printers in the United States, 69% of the printing managers reported having a specific productivity improvement program in place (Roth, 1993). While many printing organizations are actively involved in some sort of quality improvement activity, little effort has been made to assess the impact of these quality and productivity improvements. There was a growing need among printing organizations in Iowa actively involved in quality improvement efforts to measure the extent of quality and productivity improvements. In their

quest to benchmark quality and productivity improvement efforts, these organizations expressed the need to measure quality and productivity practices over time, identify improvement opportunities, and maintain the momentum of quality and productivity improvement activities in the printing industry. The Malcolm Baldrige award, the Deming Prize, and the National Association for Printers and Lithographers (NAPL) Management Plus award are some of the awards that are used by industry for benchmarking quality and productivity excellence. Garvin (1991), believes the Malcolm Baldrige award is well developed and is all encompassing to reward quality management and management excellence.

Malcolm Baldrige Quality Criteria

According to Roth (1993), the heart of productivity improvement and quality management is measurement. Farger (1991) added that measurement, based on a set of standards or guidelines, allows an organization to review its current practices, competitive strategies, policies, procedures, leadership, human practices, employees and management attitudes towards customer focus, quality and productivity.

In 1988, the United States Department of Commerce initiated the Malcolm Baldrige National Quality Award framework to evaluate the extent to which a company implements total quality manage-

ment, and to recognize American organizations that were doing an exceptional job providing quality services and products to their customers. The Baldrige award examination process is based upon an assessment of seven different criteria of data about an organization. The seven criteria include leadership, information and analysis, strategic quality planning, human resource utilization, quality assurance, quality results, and customer satisfaction. Farger (1991) stated that using the Baldrige quality and productivity criteria is the first step towards coordinated productivity and quality improvement steps that move organizations toward excellence. In a recent survey to measure what the United States business community really thinks about the Baldrige criteria for assessing quality and productivity. Knotts et al. (1993) stated that industrial and service firms, both large and small, consistently agree it provides the best framework for measuring improvements. According to Edosimwan and Savage-Moore (1991), the criteria offer a framework for improvement for business struggling with an appropriate method to assess their total quality posture.

Statement of the Problem

According to the review of literature, printing organizations have not used the Baldrige quality criteria to measure the effectiveness of quality and productivity improvements. The problem addressed by this study was to use the Baldrige quality criteria to investigate the differences in the status of quality and productivity improvements as perceived by upper management, middle management, and workers in selected printing organizations in Iowa with varying lengths of company-wide quality implementation.

Purpose of the Study

The primary objective of this study was to measure the effectiveness of quality and productivity practices in selected printing organizations in Iowa using the Baldrige criteria. In particular, the study investigated the differences in the status of quality

and productivity practices as perceived by upper management, middle management, and workers in these printing organizations which had varying lengths of company-wide quality implementation. The research attempted to answer the following questions:

1. What are the differences in perceptions by upper management, middle management, and workers towards quality and productivity practices based on the seven criteria as defined in the Baldrige framework?
2. What are the differences in perceptions towards the seven Baldrige criteria by management and workers with different lengths of company-wide quality implementation?

Based on these research questions the following hypotheses were formulated for the study:

H01: There is no significant interaction between the perceptions of upper management, middle management, and workers, and the seven criteria as defined in the Baldrige framework.

H02: There is no significant interaction between the varying lengths of company-wide quality implementation, and the seven criteria as defined in the Baldrige framework.

Limitations of the Study

The study was conducted with the following limitations:

1. The scope of the study was limited to upper management, middle management, and workers in selected printing organizations in Iowa.
2. The results of the study were suggestive of the quality and productivity improvement practices of the printing industry.

Methodology

The study was primarily descriptive in nature and yet contains causal, comparative, experimental, and correlational elements (Borg & Gall, 1993). The

method and procedures for conducting the study were divided into the following sections: definition of population and identification of sample; development of instrument; procedures for data collection; and statistical analysis of the data.

Definition of Population and Identification of Sample

Printing organizations were selected using the criteria of pursuing quality improvements based on Deming's quality philosophy. The researcher obtained a list of the printing organizations from the Center for Continuous Quality Improvement situated at Iowa State University Research Park. The nine printing organizations included two large, three medium, and four small organizations based on the classification system used by the Printing Industries of America (PIA). The sample contained 330 subjects grouped into three categories (upper management, middle management, and workers).

The dependent variables of the study were the perceptions of the respondents as measured on a Likert scale from one to seven, with 1 = disagree, and 7 = agree. A split plot factorial design was used with the following independent variables:

1. job classification (categorical variable): upper management, middle management, workers;
2. length of company-wide quality implementation (continuous variable); and
3. the seven criteria as defined by the Baldrige framework: leadership; information and analysis; strategic quality planning; human resource utilization; quality assurance; quality results; and customer satisfaction (categorical variable).

Development of Instrument

A Quality and Productivity Survey (QPS) instrument was developed to collect data for this study. The development of the instrument included the format criteria, overview of the initial instrument, review of experts, and pilot testing.

Format criteria: Subjects were surveyed using the QPS instrument developed for the study. Section A of

the instrument elicited information regarding the status of the respondent in the organization. The researcher classified the respondents into upper management, middle management, or workers based on their span of responsibility in the organization. Section B consisted of information regarding the length (in months) that the respondent had worked in the organization. Section C elicited information regarding perceptions of quality and productivity toward each of the seven criteria as defined by the Baldrige framework.

Overview of the initial instrument: The QPS instrument had forty-nine questions with seven questions for each of the criteria as defined in the Baldrige framework. An item specification table was developed based on the seven criteria as defined by the Baldrige framework to provide content and structure for each of the items in the QPS instrument. The instrument was validated by a knowledgeable panel of twelve from academia and business with expertise in quality and productivity to assure content and face validity. It was pilot-tested for clarity and readability and final modifications were made.

Pilot testing: Pilot tests were conducted on the QPS instrument to develop an useful instrument. Two rounds of pilot testing were conducted prior to administering the QPS instrument to the sample. The first round of testing was done with a group of 20 graduate students to determine readability and clarity of the QPS instrument. The instrument was modified based on the feedback from this group. The modified instrument was pilot-tested for the second time with a selected group of workers in Printing Services at Iowa State University. The purpose of the second round of pilot testing was to verify the clarity and readability of the QPS instrument. There was a consensus from this group of employees—consisting of top management, middle management, and workers—that the degree of readability and clarity was adequate and further modifications to the instrument were not necessary.

Data Collection Procedure

Approval was obtained from the Iowa State University Human Subjects Committee. A letter was sent

Demographic Variables	Frequency	Percentage
Upper management	18	6.0
Middle management	49	18.0
Workers	212	76.0
Length of company-wide quality implementation (E)		
6 months	106	38.5
12 months	41	15.0
18 months	9	3.7
24 months	43	15.7
30 months	60	21.8

Table 1. Frequency and percentage distribution for job classification and length of company-wide quality implementation

to the sample of nine printing organizations in Iowa, requesting permission to collect data. The researcher then administered the QPS instrument to the selected printing organizations. An effort was made to administer the instrument to all employees in the sample of printing organizations.

Statistical Analysis of the Data

Statistical techniques were used to test the research hypotheses. Measures of central tendency and variability were calculated for the responses toward the seven criteria as defined in the Baldrige framework (49 questions in all) in relation to job classification, and company-wide quality implementation. The statistical procedure used for the variables was the Analysis of Variance (ANOVA). A value of Cronbach's alpha was computed to determine reliability coefficients for each of the seven Baldrige criteria and for the overall instrument.

Findings

Two hundred and eighty-nine usable responses were obtained from upper management, middle management, and workers in organizations with varying lengths of company-wide quality implementation. A summary of descriptive statistics pertaining to the two demographic variables is shown in Table 1. The varying lengths of company-

wide quality implementation (E) were categorized based on the cumulative percentages to provide three experience levels for the split plot factorial design. The alpha reliability coefficients calculated for each of the seven Baldrige criteria ranged from 0.88 to 0.94, indicating a high degree of reliability for the instrument.

The numerical results of the means and standard deviations of the perceptions towards the seven Baldrige criteria for job classification and company-wide quality implementation are shown in Tables 2 and 3. The lowest perception was given a value of one while the highest perception was given a value of seven. The score for each of the seven Baldrige categories ranged from seven (minimum) to 49 (maximum). Among the seven criteria the lowest mean scores were reported for the human resource utilization criterion while customer satisfaction criterion received the highest mean score. Workers had low perceptions towards the effectiveness of utilizing human resources in their organizations, while upper management had more positive perceptions than middle management. The effective utilization of information and analysis recorded the next lowest mean among the respondents.

The mean perception towards the effectiveness quality and productivity improvements based on all seven of the Baldrige quality criteria showed a steady improvement as quality implementation in organizations were approaching 24 months. For organiza-

Baldrige criteria	Upper management		Middle management		Workers	
	Mean	Std dev.	Mean	Std dev.	Mean	Std dev.
Leadership	34.59	8.52	31.98	7.45	30.11	8.97
Information & analysis	29.33	8.03	28.73	8.95	29.34	8.86
Strategic planning	31.59	6.86	31.00	7.96	31.29	8.76
Human resource utilization	27.29	7.29	23.07	0.11	24.93	10.09
Quality assurance	30.88	7.71	29.74	8.91	30.24	8.97
Quality results	30.55	8.01	31.21	9.92	29.99	8.37
Customer satisfaction	32.65	7.44	31.21	9.21	33.43	8.19

Table 2. Mean perceptions using the Baldrige criteria for the three quality implementation level

Baldrige criteria	< than 6 months		6-24 months		> 24 months	
	Mean	Std dev.	Mean	Std dev.	Mean	Std dev.
Leadership	28.09	8.63	33.02	8.48	31.64	8.37
Information & analysis	27.30	7.77	30.19	9.54	30.74	8.80
Strategic planning	29.14	8.78	32.63	7.88	32.88	8.20
Human resource utilization	24.57	9.28	25.15	9.91	24.59	10.42
Quality assurance	27.84	7.96	31.35	9.30	31.96	9.42
Quality results	28.05	7.65	31.89	9.39	30.43	7.73
Customer satisfaction	32.83	7.35	32.64	9.62	33.56	8.09

Table 3. Means and standard deviations of the perceptions of respondents towards each of the seven Baldrige criteria for three levels of company-wide quality implementation

tions with longer than 24 months of company-wide quality implementation, perceptions were more positive in the information and analysis, strategic planning, quality assurance and customer satisfaction categories. However, the mean perceptions towards leadership, human resource utilization and quality results dropped as the length of company-wide quality implementation continued past 24 months. The factorial analysis of the of variance data for perceptions towards quality and productivity is shown in Table 4.

There was a significant interaction between the perceptions of upper management, middle

management and workers, and the seven Baldrige criteria at the 0.05 significance level using the ANOVA procedure. A graphical representation of the interaction is displayed in Figure 1. There was a significant difference among the three levels of company-wide quality implementation. Further there was a significant interaction between the levels of company-wide quality implementation and the perceptions towards the seven Baldrige criteria. A graphical representation of the interaction is displayed in Figure 2.

A post-hoc test was performed using Duncan's comparison of means test. Differences were found

among each of the seven criteria. Significant differences were found among the customer satisfaction category, strategic planning and leadership categories, the quality assurance and quality results categories, information and analysis category, and the human resource utilization category.

Implications for the Printing Community

The findings of this study provide valuable insights into the impact of the length of company-wide quality implementation, job classifications, and the Baldrige criteria as an internal tool for measuring the status of quality and productivity. Discrepancies in the perceptions towards effective practices of quality and productivity by management and workers were observed, particularly the utilization of human resources within these printing organizations. It is clear that leadership in these organizations should put into place effective mechanisms for maximizing the human resource function. According to Mohr-Jackson (1994), organizations moving towards total quality should adapt effective people policies and recognize the importance and the potential of their workforce and facilitate developmental and training strategies.

The perceptions towards quality and productivity by the respondents were significantly different for

varying lengths of company-wide quality implementation. The perception towards the status of quality and productivity steadily improved for organizations with up to 24 months of quality implementation. The implementation of total quality, which primarily included education and training, and team building activities, had a positive influence towards quality and productivity. However, the perceptions towards the status of quality and productivity dropped as the length of company-wide quality implementation continued above 24 months. This implies that these printing organizations should re-evaluate their current quality implementation systems and address the following questions: Are the current improvement techniques based on Deming thought process adequate to make further improvements? Should improvement techniques such as design of experiments, supplier improvement techniques, and competitive benchmarking be adapted? Are the technical training and workplace literacy skills adequate to contribute towards further improvements? Is there a system in place to recognize quality improvement efforts and to provide incentives for employees for making further improvements in quality and productivity? Are effective procedures used for data collection and analysis towards further process improvement?

The researchers acknowledge the need for future studies to include different geographical areas with a

Source	df	SS	MS	F	Pr > F
C	2	198	99	.27	.7670
E	2	3,030	1,515	4.05	.0185*
C*E	4	496	124	0.33	.8566
B	6	10,088	1,681	73.03	.0001*
B*E	12	1,241	103	4.49	.0001*
C*B	12	678	56	2.45	.0036*
C*B*E	24	1,350	56	2.44	.0001*
* p < .05					

Table 4. Analysis of variance of responses towards the seven Baldrige criteria and the tests of hypotheses using the ANOVA MS for S(C*E) as an error term

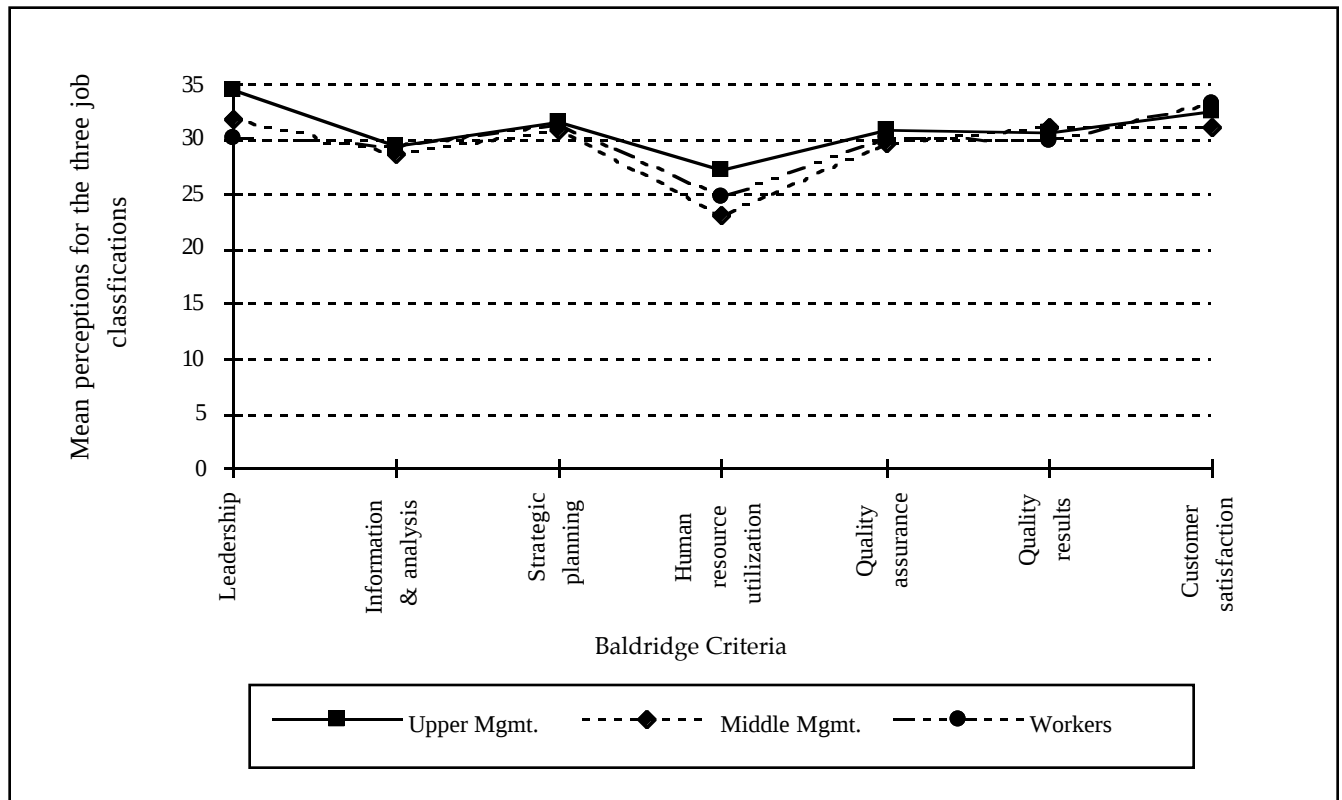


Figure 1. Mean perceptions using the Baldridge criteria for the three job classifications

focus on larger printing organizations, different TQM implementation systems and the use of variables such as training and workplace literacy skills to improve perceptions towards quality and productivity.

Implications for Industrial Teacher Educators

The Malcolm Baldrige quality criteria has become a powerful tool for measuring the effectiveness of quality and productivity improvements in printing organizations as a result of TQM transformation efforts. It is increasingly being used by world class printing organizations to benchmark quality and productivity excellence and to identify improvement opportunities.

Industrial education teachers and students need to be familiar with the Malcolm Baldrige criteria as a means of assessing quality and productivity improvement efforts in print organizations. Incorporation of the Malcolm Baldrige as a philosophy for understanding quality and productivity and using it as a refer-

ence for quality policies and practices, into industrial education and technology curriculum especially in printing will broaden students knowledge of current trends in industry. Specifically, teacher preparation programs relating to graphic arts technology and management should focus instructional strategies toward the areas of human resource utilization, the effective use of information for process improvement, and leadership relating to influences on human performance, including the design of the work itself; personnel selection, training, the physical environment; and workplace literacy skills. By doing so industrial education and technology graduates can contribute towards making significant productivity improvements and further the strategic competitive advantages of US industry.

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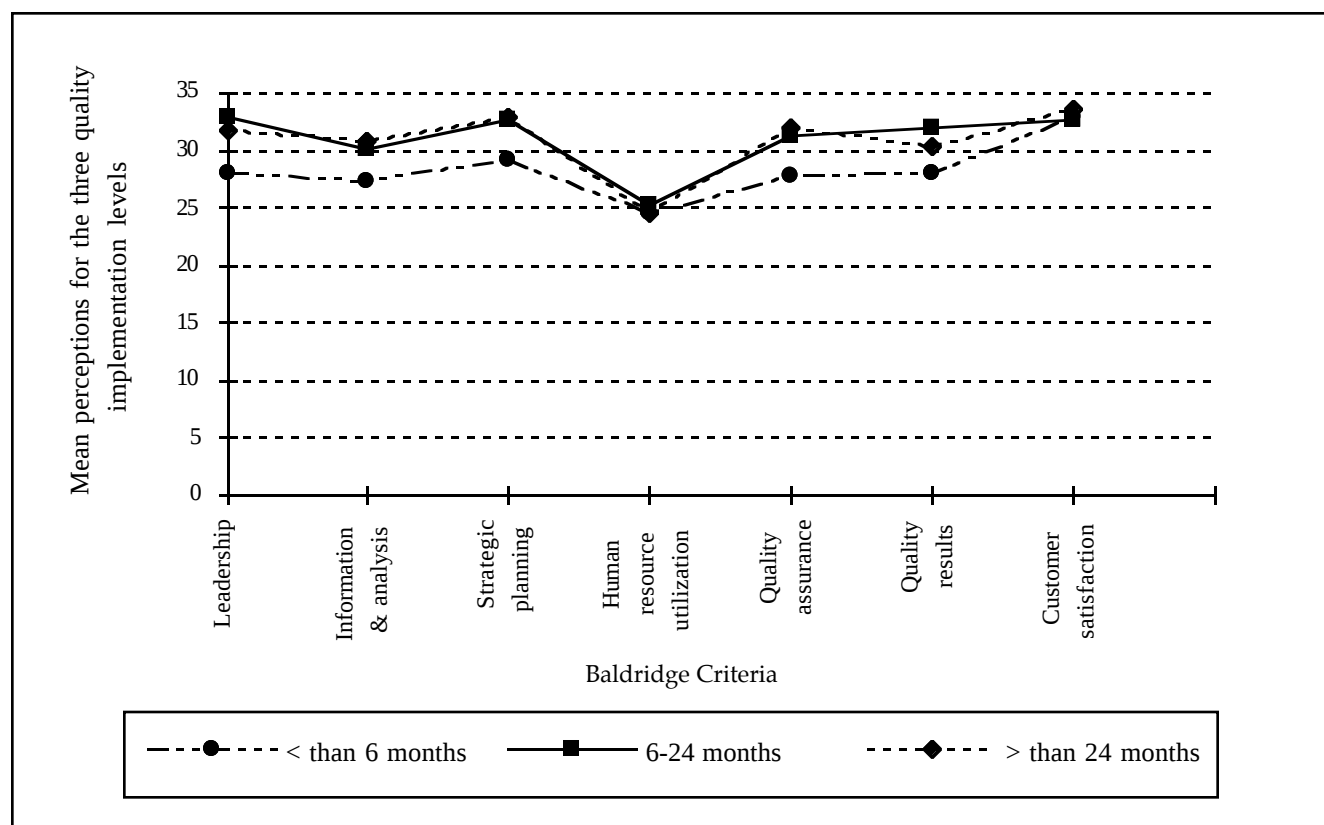


Figure 2. Mean perceptions using the Baldrige criteria for the three quality implementation levels

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A Review of Workplace Literacy Training in the Printing Industry

by Gregory G. Rauch and Jane A. Liedtke

Introduction

The printing industry is constantly in a state of change. The introduction of new systems, software, and techniques require skills and training to stay on top of technological advances. Carnevale, Gainer, & Meltzer (1990) stated, "The workplace is changing and so are the skills that employees must have in order to change with it" (p. II).

Because technical skills are changing, industry personnel need a firm grasp of the basic skills in order to learn the new skills. As new technologies and production methods are brought into the workplace to help companies stay on the competitive edge, workers are required to adapt. For example, printing systems have moved to the digital era. Files can now be sent from electronic prepress systems directly to the press, bypassing the film and plate process, saving companies time and money.

Not only is the mastery of new technologies important to the printing industry, the understanding and proper use of statistical quality control and continuous quality improvement are essential to customer satisfaction. "If quality does not meet customer's specification, future and even current contracts may be jeopardized" (Carnevale, Gainer, & Villet, 1990, p. 114).

Because of the demand for quality, training in statistical quality control and continuous quality improvement is essential for the printing industry to stay competitive, especially with the increased interest in ISO 9000. It is important to master new technology, but determining and overcoming quality

issues, by means of computation and critical thinking, is equally important.

Basic academic skills—reading, writing, and computation—have long been revered as the keys to success in society and the workplace. In theory, these skills have been essential, but in practice, workers have often succeeded because of a "strong back and willing hands" (Carnevale, Gainer, & Meltzer, 1990, p. 10).

Today, technical and quality control skills cannot be achieved if the worker can not functionally read, write, or perform simple mathematical computations. It is estimated that between 23 and 27 million people in the United States are considered functionally illiterate (Cross, 1990). As these people enter the work force, lacking needed literacy skills, companies must invest in remedial skills training before preparing employees on new technology and procedures for quality.

Background

Illiteracy has become an epidemic in the United States. Employees are coming to work lacking the needed skills to perform necessary tasks such as reading, writing, computation, and the ability to use critical thinking skills which affect quality and productivity in production settings. A review of literature is presented to shed light on this issue.

Literacy/Illiteracy

Illiteracy has been a long standing problem in the

United States. The inability to read, write, and compute has put many Americans in a less-than-capable position from which they often cannot get out. The definition of literacy, according to the National Literacy Act of 1990, is:

The knowledge and skills necessary to communicate, including the reading, writing, basic skills, computation, speaking and listening skills normally associated with the ability to function at a level greater than the eighth grade level so that education, employment, citizenry, and family life is enhanced (Cross, 1990, p. 67).

An extremely large population in the United States does not possess the knowledge or skills to pass the National Literacy Act's definition of literacy. Although these people are seen in day to day life performing common tasks, they are not performing the tasks at a satisfactory level of comprehension. This population is considered to be functionally illiterate. According to Coates, Jarratt, & Mohaffie (1990), 20–26 million people in the United States are functionally illiterate. Functional illiteracy directly relates to the ability to read, write, and compute in every day situations (Shubin, 1993). This is not recognized easily. The functionally illiterate exist in almost every facet of life. They include almost every type of person in America: co-workers, bosses, neighbors, and friends. An alarming 1.5 million people are added to the ranks of the functionally illiterate every year (Perrine, 1989).

The nation's test scores in the three R's, reading, writing, and arithmetic, have dropped considerably. A national survey of 36,000 students showed that 80% of third grade students, 50% of eighth grade students, and 36% of eleventh grade students did not perform to their expected ability in a reading-performance study. Compared to other countries in mathematics, United States students scored 46% on an international math test in 1982, compared to Japanese students with 64%. The average score among eleven nations on an international math test was 52%. Also in 1982, the top five percent of US twelfth grade students ranked last among nine

countries (Coates, Jarratt, & Mohaffie, 1990).

As American students enter the work force, the problem of illiteracy is compounded. Unfortunately, 65% of the nation's work force reads at an eighth grade level or lower. This causes problems in industry because at least 70% of worker reading material, such as safety information, is written at a ninth grade level or higher. This leaves a large gap between the skills possessed by employees and the skills they need (Smith, 1995).

Illiteracy has become more noticeable in industry in recent years. As industry becomes more advanced, skills needed for workers to stay abreast with technology increases. Skills transfer and additional job tasks have also increased the need for employees to possess greater skills. Yet workers cannot keep up with technology, skills transfer, or additional job tasks if they lack the necessary basic skills. A labor shortage, due to an aging work force and downsizing, requires that existing employees in a company pick up the slack. Employees originally thought of as unqualified are now trying to perform the tasks for which they are not qualified (Carnevale, Gainer, & Schulz, 1990; Shubin, 1993).

The problem of unqualified, functionally illiterate workers has cost businesses \$20 billion a year (Halpert & Gundry, 1991). Additional job tasks, such as simple statistical process control, are difficult for functionally illiterate workers. Research in 1992 for the U.S. Department of Education's Adult Literacy Survey showed that almost 50% of 26,000 adults encountered trouble with challenging literacy tasks or to perform "quantitative tasks involving two or more operations and requiring the individual to set up the problem" (Frazee, 1996, p. 115).

The printed word is used in all facets of life. It is used to create menus, magazines, books, and packaging for every day needs or pleasure. Printed material is also used in the work place in the form of memos, learning guides, technical manuals, and Material Safety Data Sheets, to name a few. All of these items are useless if a worker cannot read them. Literacy directly affects the printing industry. "No industries stand to lose more financially from growing illiteracy than printing and publishing"

(Printing Impressions, 1992, p. 10). Programs have been developed to combat illiteracy, yet they could fall to the wayside if there is no financial support. Programs such as PLUS (Project Literacy U.S.) and GALA (Graphic Arts Literacy Alliance) try to raise awareness and to help fund workplace literacy as well as social literacy programs.

Literacy and Training

In today's industry, employers are looking for employees who not only possess basic workplace skills, but also have more advanced skills. Carnevale, Gainer, and Meltzer (1990) developed seven skill groups that employers expect of employees: (1) learning to learn, (2) the 3 R's (reading, writing, and computation), (3) communication (listening and oral), (4) creative thinking and problem-solving, (5) self esteem and goal setting, (6) interpersonal, negotiation, and teamwork, and (7) organizational effectiveness and leadership. Employers have complained that their workers lack the ability to conceptualize, organize, and communicate. Some of these deficiencies can be overcome by one common theme: literacy training.

Although employers search for employees who own these skills, few offer the training needed to obtain the skills. Shubin (1993) cited a survey conducted by the Olsten Corporation of 400 companies. More than one-third of the companies recognized a need for work place literacy training to increase basic skills. Of the companies, 80% believed their employees needed improvement in writing skills and 75% believed their employees needed improvement in interpersonal skills. Only 25% of these companies instituted a formal literacy training program.

Another study by Anderson (1993) reported the findings of 1,011 respondents from the Society of Human Resource Management. The study was designed to determine the extent of work place illiteracy, management attitude toward work place illiteracy, and problems and solutions to deal with illiterate workers. From the study it was determined that less than 40% of the respondents offered basic

skills training "despite a very broad definition of basic skills training. (B)asic skills training was defined as any organizational effort to help illiterate employees upgrade their skills" (p. 287).

Money and time each play a key role for companies offering any type of training. While companies want employees with sophisticated skills such as those identified in the seven skills groups, they often limit their spending and time allotted for training for employees to obtain such skills. In 1994, *American Printer* and the National Association of Printers and Lithographers (NAPL) conducted a survey. Responses were received from companies ranging from two to 1,400 employees. Although almost two-thirds of those surveyed formally budgeted for training, 50% spent \$250 or less annually per employee. Almost 31% spent between \$251 and \$750 annually per employee while only 18% spent over \$751 a year per employee. Not only did the respondents differ on the amount of money spent on training, they also differed on the amount of time spent on training. Almost 44% of those surveyed averaged less than one week of training per employee per year. Thirty-two percent averaged one full week, 9% offered an average of two full weeks, and 16% offered over two weeks of training per employee annually.

WorkPLACE Literacy Program

Printing companies can access a unique training program called the NAPL's Carl Didde WorkPLACE Program. It has been the only industry-specific skills training program offered to the printing industry since 1990 (Lowther, 1995). The WorkPLACE Program consists of four courses: (1) Math Computation, (2) Critical Thinking and Problem Solving, (3) WorkPLACE Communications, and (4) the Graphic Arts Process.

The Math Computations course is designed to teach mathematical situations encountered in the printing industry such as averages and means, ratios and proportions, estimating, measuring, and an introduction to statistical process control. Critical Thinking and Problem Solving covers topics that can

also be applied to the printing industry's use of statistical process control such as identifying problems, determining and implementing appropriate action, and evaluating the results. WorkPLACE Communications focuses on reading and writing skills. Again, this is applied specifically to the printing industry by training employees how to read or write items such as job tickets or plant memos and to communicate with clients or colleagues. The Graphic Arts Process course is designed to teach employees the entire printing process and to concentrate on a printing plant's work flow (Ferris, 1991). A skills inventory is administered, which is voluntary and strictly confidential, and is evaluated by an outside source to determine which courses are needed (Vinocur, 1990).

Of those who had taken the WorkPLACE Skills Inventory as of June, 1992, it was discovered that 73% had problems reading and comprehending a standard plant memo; 50% could not accurately read a ruler to 1/16 or 1/32 inch mark; and 85% could not interpret information from a chart to set up a multiple step math problem (American Printer, 1992). Over 11,340 people within the graphic arts industry have participated in the program since its inception (NAPL, 1996).

Quality and Productivity in the Printing Industry

Quality and productivity must be at a high level in the printing industry in order for firms to compete. Quality and productivity also has strong links to a literate work force. Levenson stated, "Illiteracy affects our ability to compete. As the baby boomers age and the labor pool shrinks, business must hire workers whose skills are inadequate" (Karol, 1995, p. 73). Illiterate workers lack the skills to increase quality and productivity due to low mathematics and problem solving skills. Not long ago, printing companies could afford to lose a client to competition, miss a deadline, or lose profits due to rework. Today, the printing industry is highly competitive; poor productivity and quality could be the demise of a company (Vinocur, 1990).

Many companies are focusing on meeting or enhancing their quality and productivity standards. As the call increases for quality and productivity, so does the need for a literate work force (Olsten, 1992). Team building and statistical process control have been targeted for the printing industry. Teams search for problems within the system, analyze the problems using statistical process control tools, and improve the system to satisfy client wants (Sharples, 1993). When employees are included in the decision making process, quality and productivity can improve. Literacy training helps to build successful work teams through communication, problem solving, and mathematics.

A 1989 study by the NAPL discovered 63% of the surveyed suffered negative effects due to the lack of basic skills. Incidents that were cited include equipment failure, chemical misuse, and product spoilage. Twenty-five percent of the companies believed 20% of their work force has a basic skills problem and 83% believed there was a need for the basic skills program in the industry. According to a GALA survey of members from the Association of Graphic Arts Trainers, some of these concerns were: (1) keeping workers that lack reading and comprehension skills up to date on new technologies, (2) increasing the cost of business due to poor work skills of the those employees who lack reading and writing skills, and (3) effective reading and comprehension of product instructions or procedures (Cross, 1990).

Basic job requirements in all areas of the printing industry are not being met due to a lack of basic skills. An NAPL study in 1990 stated that the bindery area reported 41% of their workers lacked adequate basic skills. The press area reported the second highest of 38% of their workers lacked basic skills. Material handlers reported 30% and the prepress area 28% (Catonsville Community College, 1995).

The printing industry is using programs such as the WorkPLACE Program to help participating companies increase quality and productivity. According to a study conducted by Catonsville Community College from 1993 to 1995, the WorkPLACE Program improved quality and productivity through literacy training. After the program was applied, spoilage,

rework, and waste decreased due to a better ability to perform math, reading, and problem solving tasks. Employee attendance, attitude, and productivity also increased. Employees also benefited from the program on a personal level. Their basic skills increased. The study found an increase in basic skills, an increase in self esteem, and an increase in self confidence to adapt to different job demands (Skills Today For Tomorrow, 1995). Employees need literacy skills along with self esteem and confidence to contribute to a quality work culture (Modern Casting, 1994). As pointed out before, according to the seven skill groups, these are the skills employers look for.

Summary

Illiteracy is at an all time high in America. As such, it is not surprising that workers in the printing industry lack basic skills, such as reading, writing, and computation, which are the building blocks for more sophisticated skills that employers want. Printing companies must evaluate and assess employees at all levels to determine appropriate action. Ignoring the problem benefits the competition and it cuts directly into a firm's bottom line. Programs such as NAPL's Carl Didde WorkPLACE Program help workers achieve the basic skills needed in the printing industry. Once the basic skills are in place, printing companies can reap the benefits of quality and productivity.

Educators must recognize problems students have in the basic skill areas. As we prepare our graduates to enter the printing industry at various levels, we must assure employers that their new employees meet all of the essential seven skill groups. First and foremost must be our assessment and diagnosis of a student's basic skills. Utilizing industry prepared tools, like the WorkPLACE skills inventory, is one way to identify problem areas. Students should then be provided with appropriate remedial instruction by trained educators within the school system. Social promotion or ignoring basic skill deficiencies renders the student who lacks the basic skills unemployable in the printing industry, thus wasting much of the time and effort spent to prepare them with technical skills.

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Integrating the Seven Tools of Quality Into Printing

by Warren Mack and John De Leon

Printing has historically been concerned with craftsmanship. Traditionally, most quality issues were negotiated by visual judgment. However, as printing and technology evolved, many quality characteristics could not be measured by the unaided eye. The rising costs of labor and materials, coupled with increasing customer demands for improved quality, have forced the graphic arts industry to change its attitudes about product improvement. Many printing companies have implemented quality control programs to help meet customer quality expectations. A quality control program embraces monitoring and modifying the process to realize customer quality standards. The task, however, lies in the acquisition of data that justifies process alterations. The seven tools of quality can be employed to aid in detecting process problems and their causes. The tools include: flow charts, check sheets, histograms, cause and effect diagrams, pareto charts and diagrams, scatter diagrams, and control charts.

Flow Charts

In order to control a process, one must first understand that process. Flow charts help to accomplish this by the integration of illustrations and symbols to simulate the process flow. Mapping the process often leads to reduced cycle times and cost savings, thus improving both the service level to the customer and profitability of the firm.

The segment identifying the process is usually displayed step-by-step using symbols. Figure 1 shows the process of making a line negative in flow chart form. In essence, flowcharts help to understand the number, sequence, and interrelationship of the steps of a process.

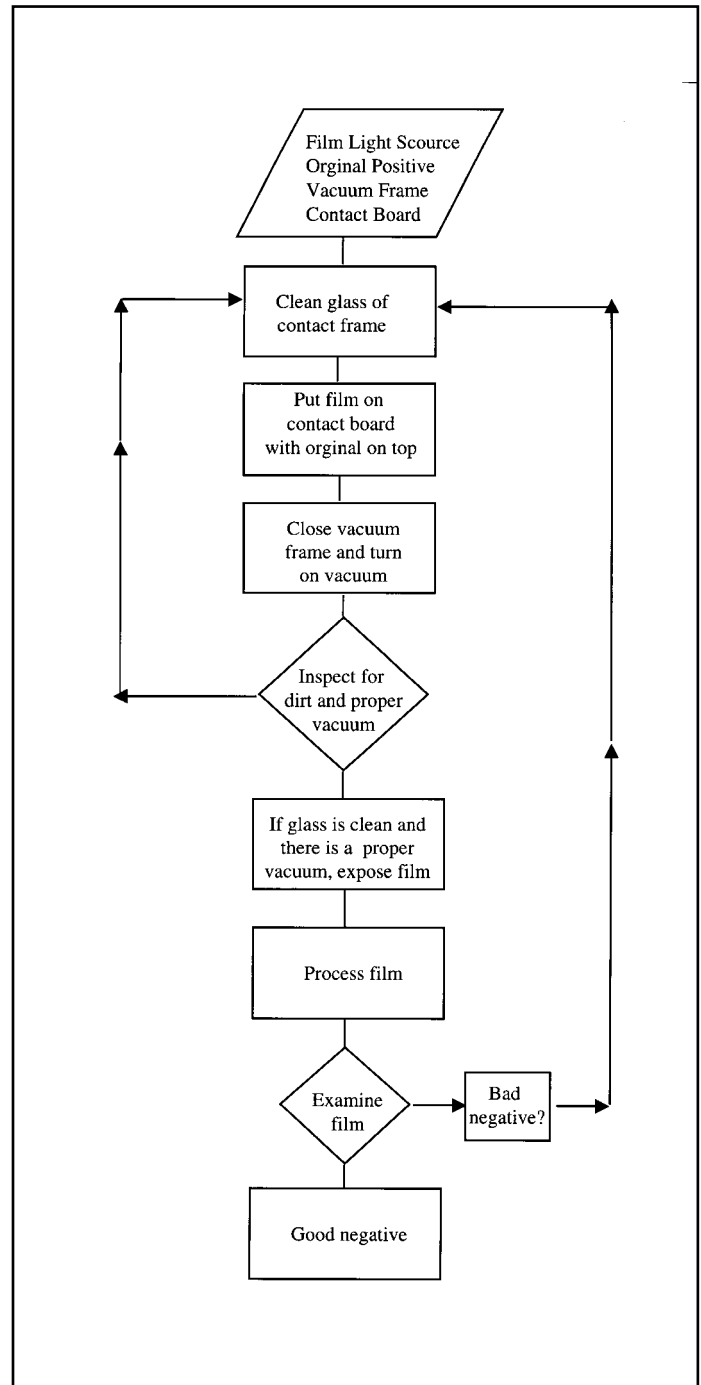


Figure 1

Date	Inspector	
Job Number	Shift	
Customer	Department	
Type	Number of Defects	Total
Hickies	XXXXXXX	7
Toning	XXXX	4
Misregistration	XXXXXXXXXXXXXXXXXXXX	
	XXXXXXXXXX	27
Color	XXXXXXXXXXXXXXXXXX	14
Creases	X	1
Streaks	XXXXXXX	8
	Total Defects	61

Figure 2. A check sheet to illustrate the number of defects by type

Check Sheets

Of all of the statistical process control techniques available, the most basic and visually effective is the check sheet. Check sheets deal with the where, who, how, and what else issues of data collection. Good

decisions are based on facts, not opinions. Facts come from data. The term check sheet is often used to describe any chart or graph where data are recorded while they are being gathered. Check sheets provide an easy way to record, analyze, and present the results in a single form. Because check sheets employ a simple and direct display of the data, they are often sufficient for initiating improvement efforts. Their simplicity makes it attractive to production operators.

The best way to explain the concept of check sheets is to look at a sample. Figure 2 contains a check sheet that illustrates the number of defects by type that may occur in a given printed product. In this case, color newsprint advertisements were inspected for a variety of problems. As shown, every time a defect is found, it is identified and tallied. The totals for each category are shown on the right side and the total number of defects is found in the lower right corner. This data indicates that misregistration is by far the most troublesome problem for this operation, while creases occur very infrequently. It would be a very simple task to determine the percentages of occurrence for each type of defect

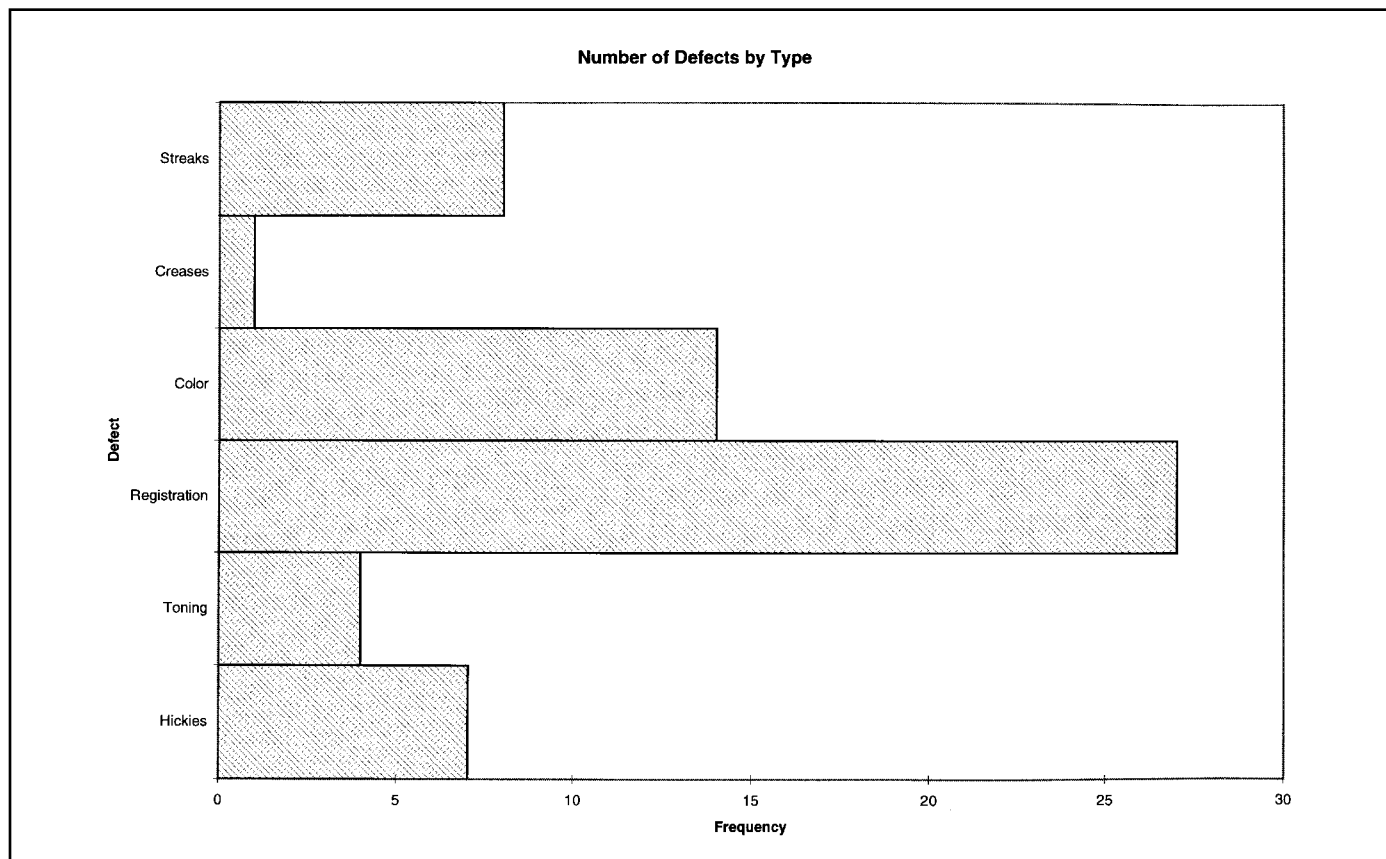


Figure 3. A bar chart of the number of defects by type

.77	.76	.75	.75	.74	.74
.77	.76	.75	.75	.74	.74
.76	.76	.75	.75	.74	.74
.76	.75	.75	.75	.74	.74
.76	.75	.75	.75	.74	.73

Figure 4. Measurements of solid ink density from a press run.

Density	Tallies	Frequencies
.73	X	1
.74	XXXXXXXXXX	9
.75	XXXXXXXXXXXXX	12
.76	XXXXXX	6
.77	XX	2

Figure 5. A tally sheet of the frequency of occurrence for each density.

from this form. For quality improvement efforts to be fruitful for this operation, they should focus on the ways of solving the misregistration problem. Often times, operators need only to see the results of inspection data in an easily understood form to recognize what errors need to be addressed.

Histograms and Bar Charts

Variation in repetitive production operations follows a pattern that can be discovered if enough observations can be made. The most common methods for learning about the pattern of variation are the frequency histogram, often referred to as the bar graph histogram, and the bar chart. Both histo-

grams and bar charts allow for pictorial representation of a large amount of process data and both can be constructed from data found on tally sheets. The difference in the two graphs is that bar charts use qualitative data (nominal or ordinal levels of measurement), while histograms use quantitative data (interval or ratio levels of data). Bar chart data cannot be quantified. Measurement values for histograms can be calculated and represent quantifiable differences. For example, the data collected for Figure 2 is qualitative, the values represent names of defects. The bar chart would take the form found in Figure 3. The histogram is a graphic display of the comparative frequency of measurements.

The basic steps in constructing a histogram of

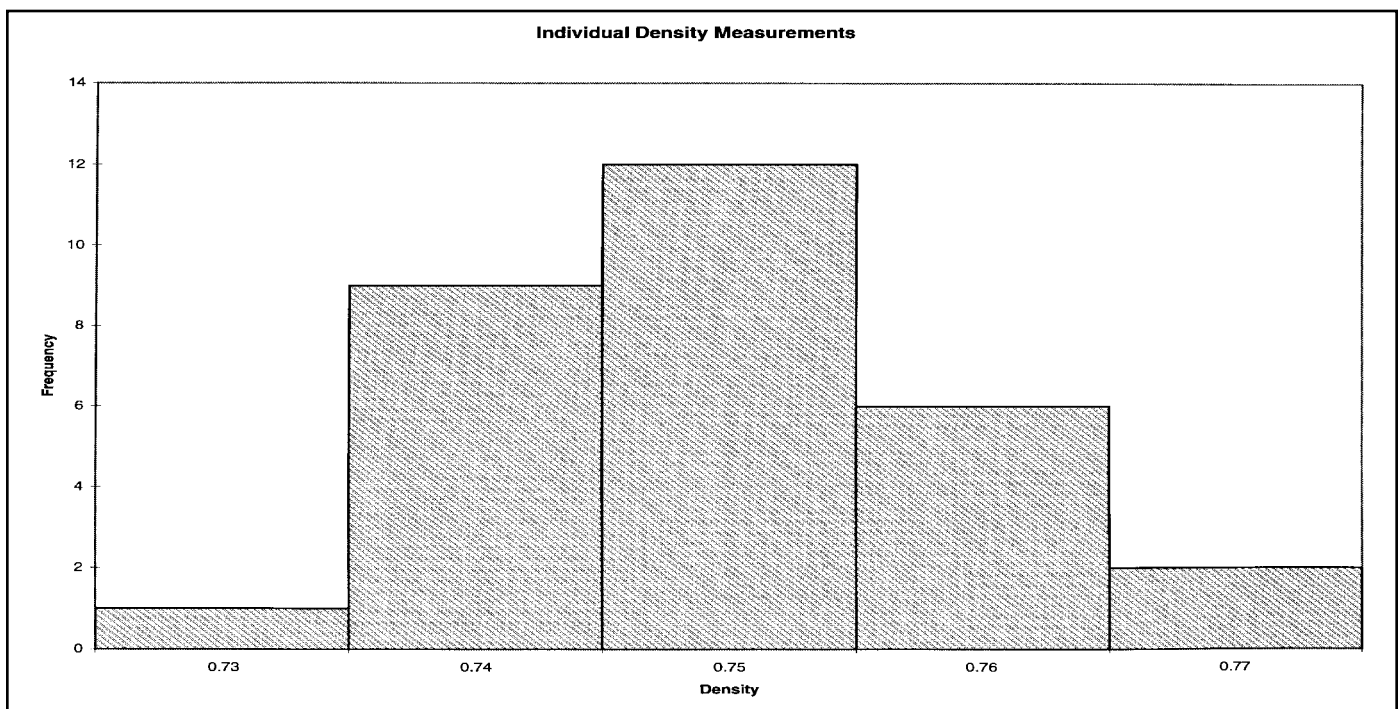


Figure 6. Histogram of individual density measurements

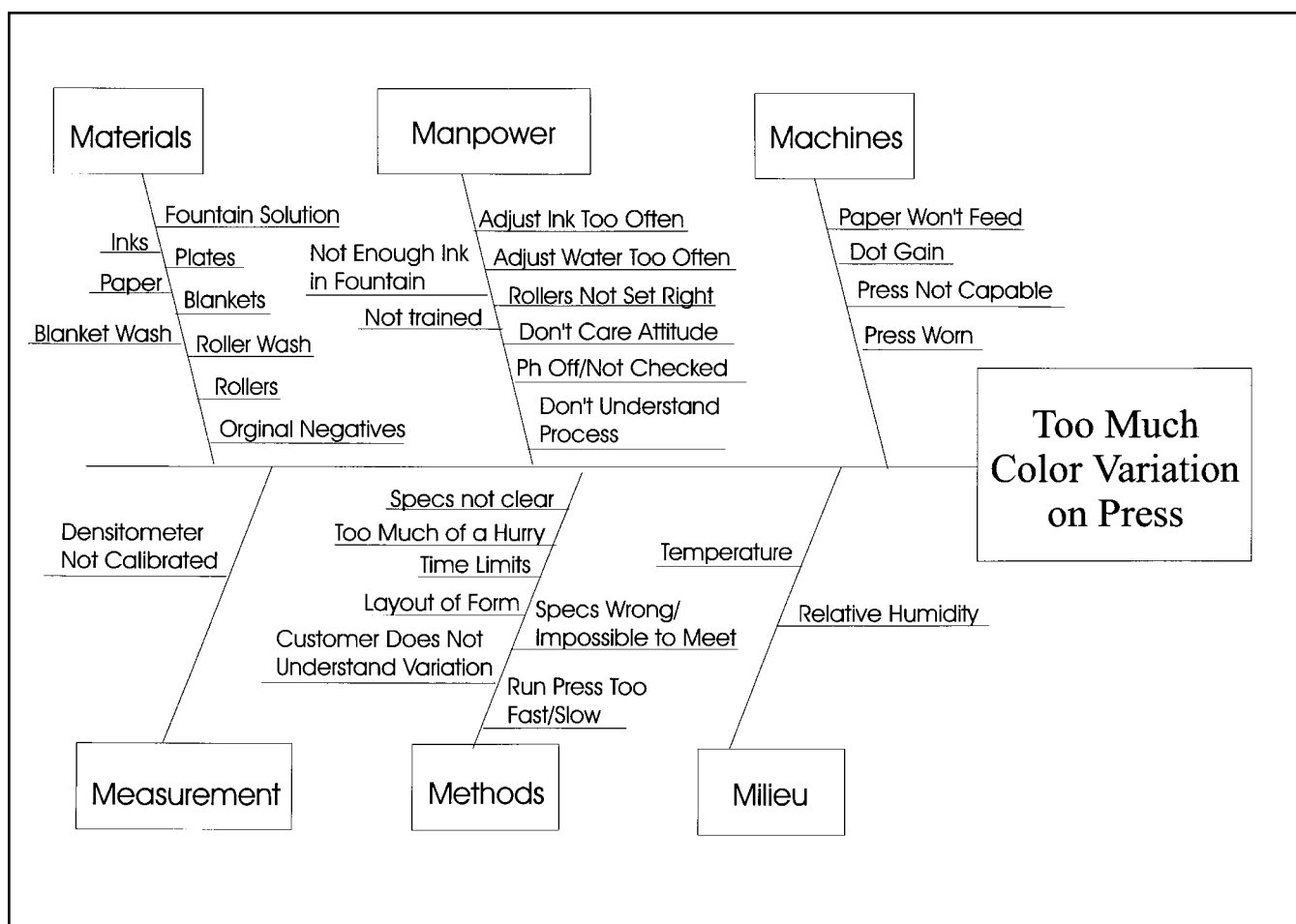


Figure 7. The relationship between a given effect and its potential causes

individual measurements are (a) determine the number of classes or intervals to be counted, (b) tally the data into these classes, and (c) determine the frequency of values in each class. An example appears in Figure 4.

Figure 4 is a representation of thirty measurements of solid ink density that were made during a press run. The measurements are organized from smallest to largest on a tally sheet where the number or frequency of occurrences of each value or class is tallied as shown in Figure 5.

A more visually pleasing picture is obtained when the tally marks are replaced with bars where the heights of each correspond to the frequency for each class. This is illustrated in Figure 6.

Cause and Effect Diagrams

The cause and effect diagram is an extremely useful tool for determining what variables or factors

are influencing a given situation. It is a modified form of a flow diagram where the desired outcome or effect can be traced to its causes. The diagram is known as the Ishikawa diagram after Professor Ishikawa of Japan, who first used it in the 1960s (Smith, 1995). It is also known as the fishbone diagram since the completed diagram resembles the skeleton of a fish. This diagram depicts the relationships between a given effect and its potential causes. Cause and effect diagrams are drawn to sort out and relate the interactions among the factors affecting a process.

The causes are usually grouped into the six main areas of quality loss: (a) materials, (b) machines, (c) methods, (d) measurements, (e) manpower (people), and (f) milieu (environment).

As seen in Figure 7, the main causes are represented by large branches off of the main line or effect. The sub causes are represented by smaller branches off each large branch. This creates a hierarchical

Defect	Tally	Total
Dirt, Hickies	XXXXXXXXXXXXXXX	15
Color Variation	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	30
Doubling	XXXXXXXXXX	10
Off-setting	XXXXXX	6
Weak Binding	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	30
Misregistration	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	45
Creases	XXXXXXX	8
Toning	XXXXX	5

Figure 8. Data tabulated from a printing plant study

relationship among the main causes and the sub causes. The sub causes could in turn have their own sub causes. The main cause has a direct relationship to the effect or condition being studied. Each of the sub causes is related in terms of its level of influence on the main cause (Brocka & Brocka, 1992). If we examine the materials cause we will see that many material factors can effect color variation on the press. Some of these factors are ink, paper, blanket wash, fountain solution, and plates.

While a cause and effect diagram can be constructed by an individual, it is most powerful when constructed by a team. One of the most valuable attributes of this tool is that it provides an excellent means to facilitate a brainstorming session. It tends to focus the participants on the issue being studied and quickly allows them to sort ideas into useful categories.

Pareto Charts

Printing production processes are quite complex. As a result, difficulty is often encountered in determining the areas needing quality improvement. However, the production of a four color printed piece is no more complex than the production of an automobile, to which many quality improvement tools have been successfully put to use. Where there are many variables present that influence quality, they must be sorted out, ranked in order of importance, and then investigated to find ways of controlling them. In other words, before we can take actions that begin to improve process performance, we must first determine where to focus our effort.

Any action taken to improve quality and productivity has an initial cost associated with it. Thus, it is necessary to determine where the quality improve-

Order	Defect	Frequency	% of Defects	Cumulative %
1.	Misregister	50	31%	31%
2.	Weak Binding	37	23%	54%
3.	Color Variation	30	19%	73%
4.	Dirt, Hickies	15	9%	82%
5.	Doubling	10	6%	88%
6.	Creases	8	5%	93%
7.	Off-Setting	6	4%	97%
8.	Toning	5	3%	100%
	Total	161	100%	

Figure 9. Pareto chart showing rank order of defects

ment dollars should be spent to yield their greatest likely return. While it is true that there are hundreds of things that could happen during the print production process to cause quality problems, experience shows that they neither happen with the same frequency nor do they have the same economic effect. Some quality problems are much more costly than others. Obviously, if quality improvement is to occur, these key problems, or defects, must be identified and corrected. To this end, a concept known as the Pareto principle has proven most effective.

First proposed by the Italian economist whose name it bears, the Pareto principle states that in any manufacturing system there are countless sources of defects. However, there is almost always a small number of them that contribute the most to the loss of quality. Thus, it is important to separate these vital few problems from the trivial many. This concept is known as the 80–20 rule since approximately 80% of quality losses can usually be attributed to 20% of the problems. This principle has led to the development of a quality control tool known as Pareto Analysis.

Pareto Analysis involves the following steps:

1. definition of the system or product to be studied;
2. tallying of defects or problems that occur over a given period of time;
3. ranking of the defects in order of frequency of occurrence; and
4. identification of the top two or three problems.

Consider Figure 8, which contains data tabulated from a printing plant study. The purpose was to identify reasons for poor quality in a finished product. It is clear that there were many different types of quality defects being encountered. What must be done next involves the assessment of process problems priorities. This is done by ranking the data in descending order of frequency. Next the percentage defective is given along with the cumulative percentage value is shown in Figure 9.

The results are then presented in the form of a Pareto diagram. In this diagram the categories of defects are placed on the horizontal axis from left to right in order of most frequent to least frequent. The fre-

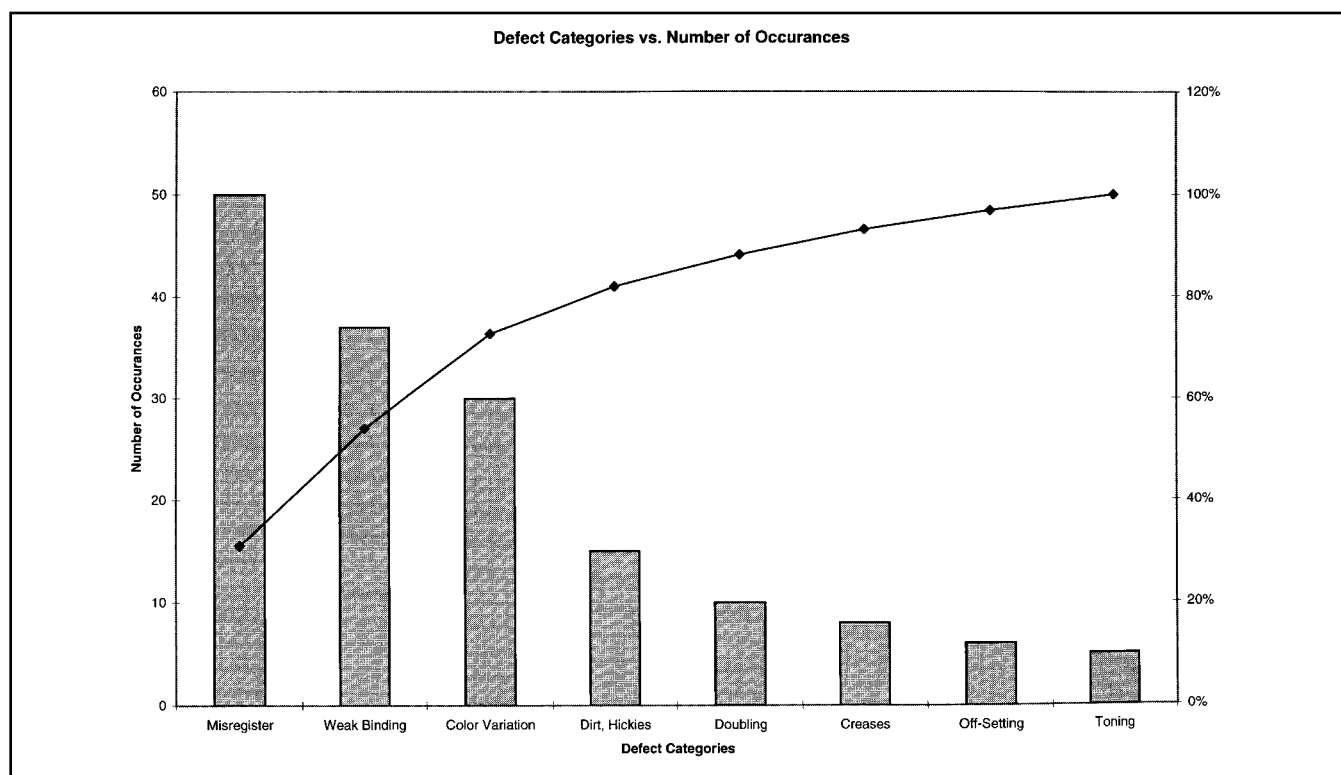


Figure 10. Pareto diagram showing defect categories against number of occurrences

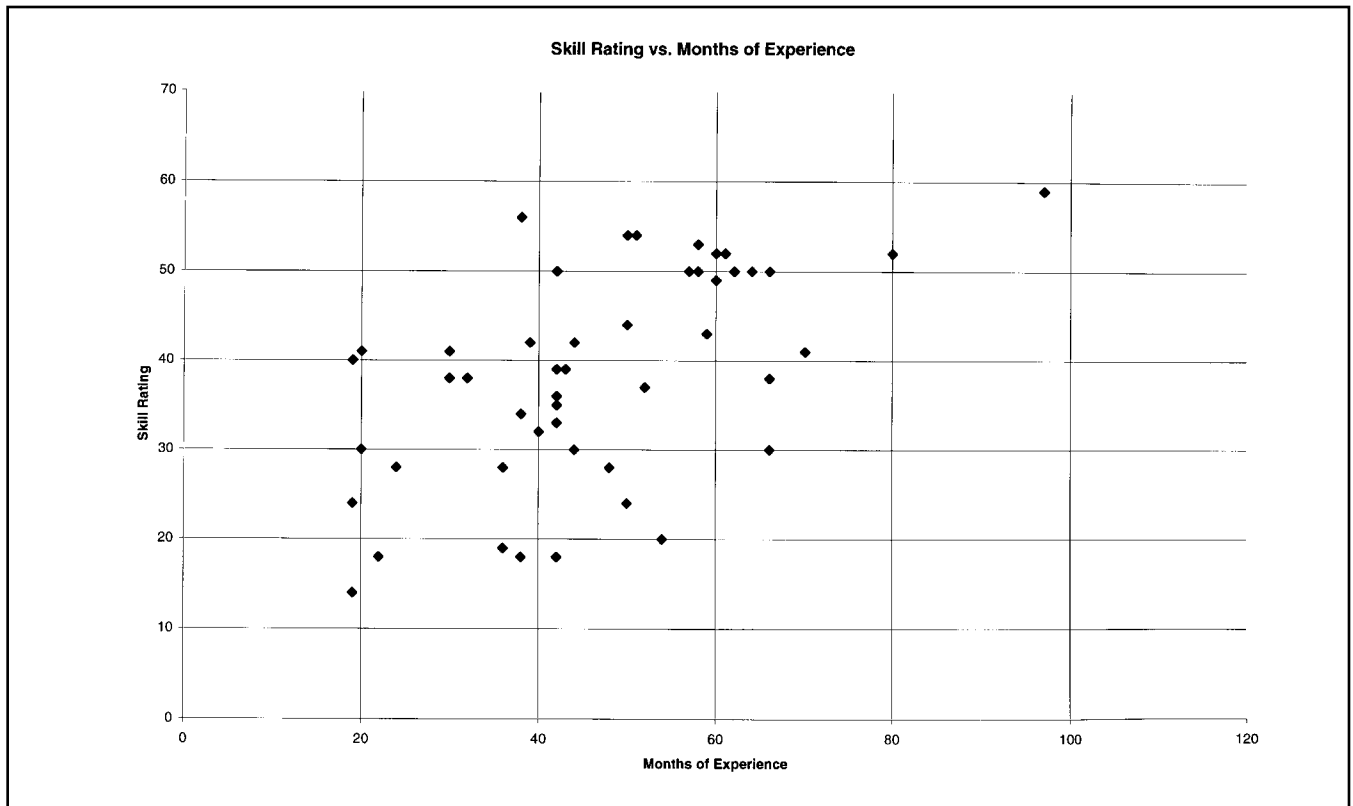


Figure 11. Scatter diagram of skill rating vs. months of experience showing a weak positive correlation

quency values are shown on the left-hand vertical axis and cumulative percent on the right-hand axis as shown in Figure 10.

Frequencies and defects are presented in the manner of a bar chart. Cumulative percentages are plotted then connected, forming a line. The line of

the plotted cumulative percentages showing the percentage of the total problem rises rapidly with the first few categories but then diminishes (straightens) as the remaining categories are included. In this case, the problems of misregistration, weak binding, and color variation (the vital few)

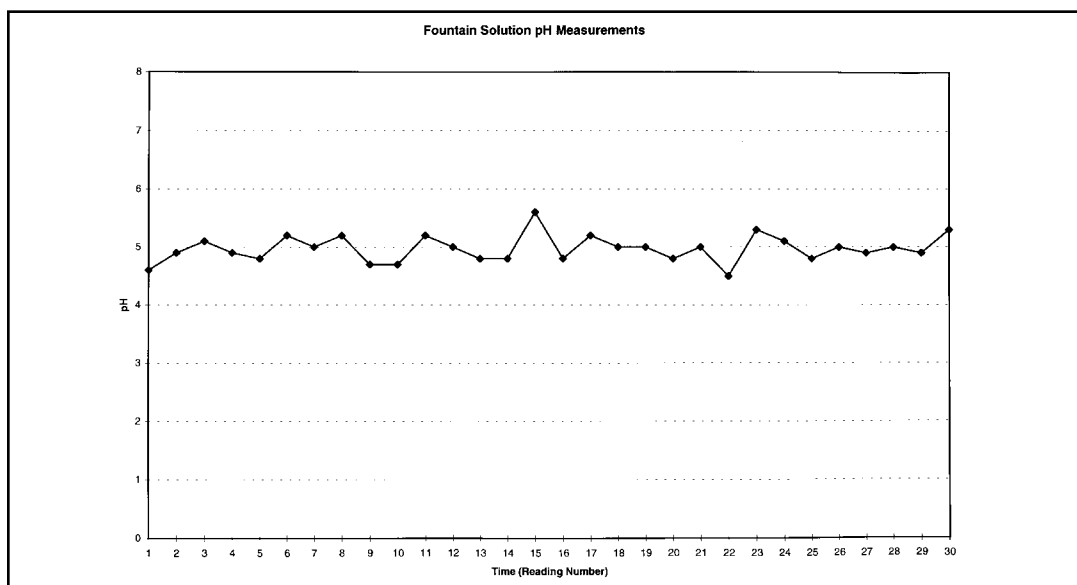


Figure 12. A control chart of fountain solution pH with one reading taken every five minutes

account for approximately 80% of the quality defects encountered. The rest of the combined defects (the trivial few) account for approximately 20% of the total defects registered.

Scatter Diagrams

The scatter diagram (Figure 11) is used to study the relationship between one variable and another. It provides a test for possible cause and effect relationships. Although it cannot prove that one variable causes another to change, the scatter diagram does clarify whether a relationship exists, as well as the strength of the relationship.

The relationship between two variables is broadly defined in one of the following ways: (a) positive—as one variable increases in magnitude, so does the other; (b) negative—as one variable increases in magnitude, the other decreases; and (c) no relationship exists. A scatter diagram is constructed so that the horizontal axis (x-axis) represents the measurement values of one variable, and the vertical or y-axis represents the measurement of the second variable. This diagram shows how the data are scattered or clustered. The direction and tightness of the scatter provides insight into the strength of the relationship between the two variables. The closer the scatter comes to forming a straight line, the stronger the relationship between the two variables.

Control Charts

There are two type of control charts: an attributes chart, and a variables chart. Attributes charts use pass-fail information for charting. An item passes inspection when it conforms to the standards; a non-conforming item fails inspection. A variables chart use actual measurements for charting. The simplest form of a variables control chart is the run chart. It provides a simple, visual display of the process

variation. It is similar in concept to the histogram, with the important exception that the data are displayed as a function of time. This time-related nature of the process behavior cannot be discovered unless the order of production is preserved, because stability is a time-related property of the process.

Summary

Any entity that produces a product or renders a service must be cognizant of customer needs and expectations. The printing industry is no exception. Consequently, if the printing industry does not constantly improve product quality, it will fall behind the demands of the customer. Once the gap is opened, it becomes very difficult to close. The seven tools presented are an excellent forum from which to assure customer quality needs and expectations.

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Altering Grayscale Images to Compensate for Press Fingerprints

by Jerry Waite

Grayscale images are generally made from black-and-white or color continuous-tone photographs. Original photographs are digitized using one of a number of scanning techniques—ranging from desktop scanners to Kodak PhotoCD equipment—and saved as computer files. Saved digital files can then be opened directly by page layout programs, such as Adobe PageMaker or QuarkXPress, placed in the desired position on a page, and then output to laser printers, imagesetters, platesetters, or digital on-demand printing equipment.

Unfortunately, grayscale images placed directly into page layout programs will probably look terrible when printed on a printing press because such images have not been altered to compensate for the effects caused by the printing process. In particular, each printing process—indeed each printing machine—causes two types of changes to the grayscale image: tone range compression and halftone dot deformation. To produce the best possible reproduction of grayscale images, it is necessary to determine the actual effect of a particular printing press on tone range compression and halftone dot deformation through careful testing. Upon completion of these tests, the unique characteristics of a press, known as its fingerprint, are recorded. The fingerprint can then be used, in conjunction with image editing software such as Adobe Photoshop, to match a given photograph to the particular press. Matching a photograph to a particular press' fingerprint will result in the best possible reproduction of a grayscale image.

This paper will describe the variables affecting tone range compression and halftone dot

deformation, describe a method for fingerprinting an individual press, then explain how Adobe Photoshop can be used to match a grayscale image to a particular fingerprint.

Variables Affecting Tone Range Compression and Halftone Dot Deformation

Copy Density Range

Original continuous tone photographs are composed of thousands of varying tones ranging from white to black. Each tone can be described in terms of its density, or darkness. The density value of any tone can be measured numerically using a special instrument called a densitometer. White tones are not very dark, so they have low density numbers near zero. Conversely, black tones are very dark, so they have high density values—2.00, for example. Middle gray tones have density values around 0.60–0.90. For a more complete explanation of density and the mathematics used to derive density values, see Adams, Faux, and Rieber (1996).

When reproducing a continuous tone photograph, two specific tones must be considered. These are the highlight and shadow. The highlight is the lightest tone in the original, and typically has a density value about 0.10. The shadow is the blackest area. Black-and-white continuous tone photographs usually have a shadow that measures 1.80–2.00. The shadow density value of color originals is usually greater than that of black-and-white originals. The copy density range is the difference between the shadow

density and the highlight density, and is calculated by subtracting the density of the highlight from the density of the shadow. By way of example, most black-and-white continuous tone photographs have copy density ranges of approximately 1.70 or higher.

Compression of Copy Density Range Due to Ink and Paper Densities

Black-and-white continuous tone photographs are generally reproduced with a printing press using black ink on white paper. The densities of white paper and black ink can be measured with a densitometer. For example, the white paper specified for a particular job may have a density of 0.15, while a solid single layer of black ink on that paper may measure 1.60. In this example, the maximum printed density range for this paper and ink combination is 1.45 (1.60–0.15). In almost all cases, the maximum printed density range will be less than the copy density range of the original—in many cases it will be much less. Because the maximum printed density range is almost always smaller than the copy density range, the copy density range of the original must be compressed to match the maximum printed density. Consequently, printed reproductions of photographs will almost always have darker highlights and lighter shadows than original continuous tone photographs.

Halftones

Printing presses are not capable of reproducing the thousands of varying shades that exist in an original continuous tone photograph. Instead, a press is only able to transfer whatever color of ink is on its rollers to the paper or leave the paper blank. The varying tones in an original photograph are simulated through the use of varying sizes of halftone dots. Light tones in an original continuous tone photograph are simulated by using small halftone dots, while dark tones are simulated with large halftone dots. Gray tones are reproduced with halftone dots that are checkerboard in shape.

Halftone dots are described in terms of the number of dots per linear inch (lines per inch, or

lpi) and the percent of the paper that the dots cover. Therefore, if there are 133 dots per linear inch and a particular dot covers 20% of the paper, that dot is known as a 133 lpi 20% dot. Generally speaking, the higher the lpi, the more pleasing the printed halftone. In most cases, due to aesthetic and technical reasons, printed halftones should not have areas that are free from dots in the highlights—unprinted paper—or areas that are covered with a solid layer of ink in the shadows.

Compression of Copy Density Range Due to Halftone Characteristics

Printing halftone dots on paper obviously increases the perceived density of the paper. For example, if the density of blank white paper is 0.15, an area covered by 10% dots could measure about 0.20. Similarly, because the shadow areas of a photograph should always contain dots rather than be printed solid, the perceived density of the shadow will be less than the density of a solid layer of black ink. Thus, if the density of solid black ink is 1.35, the perceived density of a halftone shadow could be about 1.30. Because highlights are darkened and shadows lightened by halftone dots, the achievable printed density range of a printed photograph will be less than the maximum printed density range that a combination of ink and paper can produce. Thus, the copy density range must be further compressed.

Determining Smallest Highlight and Largest Shadow Dots

Because the maximum printed density range is almost always less than copy density range, it is very important to limit further tone compression caused by halftoning. To cause the least possible additional tone compression, the smallest consistently printable halftone dot is generally positioned in the highlight while the largest consistently printable halftone dot is positioned in the shadow. Positioning of the smallest and largest printable halftone dot in the highlight or shadow, respectively, was traditionally accomplished through photographic exposures. Today, the same process is accomplished digitally using an image

editing program such as Adobe Photoshop.

Before appropriately-sized halftone dots can be positioned in the highlight and shadow, the largest and smallest printable dot sizes must be identified. Two factors are important in specifying minimum and maximum dot sizes: 1) What lpi is to be used to reproduce the photograph? and 2) What are the smallest and largest consistently printable percent dot sizes that can be printed using the chosen lpi? Four variables affect the answers to these questions: 1) the paper or other substrate; 2) the printing process; 3) the characteristics of the individual printing machine; and 4) the client's choice of lpi.

There are two broad categories of paper: 1) uncoated; and 2) coated. Uncoated paper consists of woven wood or other plant fibers. Uncoated papers are generally fairly rough—they have indentations between the individual fibers—and are highly absorbent. Because uncoated papers are rough, it is hard to print extremely small highlight dots on them—such small dots get lost in the indentations. Because uncoated papers are highly absorbent, it is hard to print large shadow dots—the paper absorbs the ink too fast, causing the dots to expand or blot. Such expanded dots overlap one another and appear solid. Coated paper is uncoated paper that has been covered with a protective layer of clay. Coated papers are smoother and much less absorbent than uncoated papers. Because they are smooth, small highlight dots are possible. Because they are less absorbent, large shadow dots can be effectively printed. In general, coated papers can handle higher lpi's, smaller highlight dots, and larger shadow dots than uncoated papers. Thus, the copy density range of the original continuous tone photograph need not be compressed as much when coated papers are used as compared to the compression necessary when uncoated papers are specified.

Many products are printed on substrates other than paper. For example, many screen-printed products are printed on textiles while many products are printed by flexography on plastic film. Each substrate will affect the optimum lpi and printable highlight and shadow dot sizes. In general, however, the smoother the substrate, the higher the lpi, smaller

the printable highlight dot size, and larger the maximum shadow dot size.

The printing process—in particular, the type of plate used by the process—impacts the maximum lpi and printable highlight and shadow dot sizes. In general, printing processes that use rigid plates are capable of producing smaller dots than processes that use softer plates. Among the commonly used processes, offset lithography and gravure have the most rigid plates and can produce the smallest lpi screens with the smallest highlight and largest shadow dots. Both flexography and screen printing use flexible plates. Neither process can print high lpi screens or extremely small highlight or large shadow dots.

Within each printing process, every printing machine has its own characteristics. These characteristics depend on the quality of the engineering used in the design and manufacturing of the machine and how well it has been maintained. Within each process, a well engineered and well maintained press will produce higher lpi's, smaller highlight dots, and larger shadow dots. Worn out or poorly designed presses cannot do as well. An often overlooked variable is the skill and carefulness of the press operator. Skilled and careful operators can often coax better halftones out of a worn out press than sloppy or poorly instructed operators can produce on a new machine.

The lpi chosen for a particular halftone can affect the smallest printable highlight and largest printable shadow dots. No matter what the percent size of a halftone dot, a lower lpi dot will be larger than a higher lpi dot. Therefore, even if uncoated paper or other rough substrate is used, small highlight and large shadow dots can be printed if low lpi screens are used. For example, in screen printing it is possible to print a 50 lpi 3% highlight dot on rough textile because the 50 lpi dots are quite large and can span the crevices between the fibers. However, if the lpi is increased to 85, screen printing can handle only about a 5% highlight dot, even on smooth surfaces.

The individual substrate, printing process, and printing machine used for a particular job will impact the lpi and printable highlight and shadow

Process/Substrate	LPI Range	Smallest Highlight	Largest Shadow
Screen printing on textiles	50	3	95
Screen printing - smooth surfaces	85-110	5	92
Flexography - all substrates	85-110	2	80
Offset lithography - coated paper	150-250	2	95
Offset lithography - uncoated paper	120-133	10	90
Gravure - coated paper	150-200	3	98
Gravure - uncoated paper	150-200	5	90

Table 1. Examples of LPI's, smallest highlight, and largest shadow dots for selected printing processes (See Note i)

dot sizes. For this reason, it is important to determine the optimum specifications for each commonly-used combination of these factors through careful testing of the press. However, in the absence of actual test data, rules of thumb for lpi and smallest halftone and largest shadow dot sizes are given in Table 1. It is important that to understand that the use of Table 1 for particular jobs is comparable to attempting to heal oneself using a medical encyclopedia—unless someone who knows what they're doing runs some tests, the strategy is just a guess!

Clients obviously have an interest in the choice of lpi used to reproduce their photographs. Unfortunately, clients often specify lpi screens that are too high for a given process/substrate combination. For this reason, it is the printer's responsibility to have printed samples of fingerprinting tests available on commonly used papers so that clients may have a visual guide to choosing an lpi screen that is appropriate for the specified paper.

Deformation of Halftone Dots

Unfortunately, halftone dot sizes specified by careful photographic exposures or through the use of Photoshop do not necessarily print the designated

size on the press. The pressure used to transfer the ink to the substrate, coupled with the blotting action of many substrates, causes dots to become enlarged or deformed. For example, if a halftone dot size of 50% is specified in Photoshop, the printing pressure and the paper's blotting action can cause those dots to enlarge to the size of 70% dots. This phenomenon is known as dot gain. Dot gain is not an error or flaw—it is an attribute of print reproduction. It does, however, make halftones look darker than they should. So dot gain must be taken into consideration when preparing grayscale images for reproduction.

In most printing processes, dot gain affects the midtones more than the highlights or shadows (see Note ii). The larger the circumference of the dot, the more likely it will be affected by dot gain. However, dots larger than 50% start to overlap, so they don't appear to gain very much. Tiny highlight dots are usually not greatly affected by dot gain either. Because of the considerable impact of dot gain on midtones, dot gain is generally measured at the 50% dot. When a press is fingerprinted, a 50% dot's size is measured with a densitometer or other dot measuring device. The dot will usually read between 65–85%, a gain of 15–35%. Fifteen percent is considered very good dot gain, 20% is normal, and

Process (paper)	Typical dot gain
Offset lithography - web (coated)	20%
Offset lithography - web (newsprint)	35%
Offset lithography - sheetfed (coated)	15%
Offset lithography - sheetfed (uncoated)	20%
Flexography (coated)	25%
Flexography (uncoated)	40%

Table 2 Examples of dot gain for various process/substrate combinations (see Note iii)

35% is very bad. Table 2 provides some rules-of-thumb for dot gain. However, you should always use the test data for a particular substrate/process/press combination to determine anticipated dot gain.

Fingerprinting an Individual Press

Each press in a plant should be carefully tested to determine the smallest printable highlight dot and the largest printable shadow dot that can be effectively reproduced at each commonly used halftone lpi. A test pattern, similar to the one shown in Figure 1, can be devised and used to test each press. The test results are known as the fingerprint of the press.

The test pattern should include individual patches of halftone dots ranging from 1%–10%, 50%, and 80–100%. The pattern should be repeated for each lpi that will be commonly used on a given substrate. For example, if the press is an offset lithographic machine and the paper to be printed is uncoated, at least 120 and 133 lpi should be represented. For an offset lithographic press on coated paper, 120, 133, 150, 175, 200, and 250 line screens should be included.

The fingerprinting target illustrated in Figure 1 was prepared using Photoshop and QuarkXPress. First, a 6×1.5" grayscale document with 266 pixels per inch (ppi) resolution was created in Photoshop. A fixed-size selection was drawn and filled with 1% black using the Color Picker and the Paint Bucket tool. The selection was then copied and pasted. The pasted copy was positioned next to the first selection and filled with 2% black. This process was repeated



Figure 1

until all 32 selections in each two-line target were filled as shown on Figure 1. The file was saved in the TIFF format. A new QuarkXPress document was created and six picture boxes were drawn. The same TIFF image was placed into each of the six picture boxes. The Picture Screening dialog box was then used to change the halftone screen lpi of each test pattern to match a screen ruling commonly used on an offset press using uncoated paper. A solid line was added to the bottom of the page to be used to check ink density and balance. (Note: Graphic Arts teachers are welcome to the Photoshop and QuarkXPress files used to create Figure 1. E-Mail the author at JWAITE@UH.EDU to receive the files by return e-mail.) In practice, the lpi of the test patterns should be adjusted to provide a representative range of lpi's for the chosen printing process/substrate combination. For example, if the fingerprinting target will be used for screen-process printing, the range of lpi's should start lower (around 50 lpi) and end lower (around 110 lpi).

After a master file similar to Figure 1 has been created, it must be carefully output on an imagesetter or, in the case of direct-to-plate, on a platesetter. The image on the resultant film or plate must be measured with a densitometer or dot area meter to be certain that the imaged dots are reasonably close to the specified sizes. Film must be measured with a transmission densitometer or dot meter, while plates must be measured with a reflection instrument. (Note: If a dot area meter is not available, standard density readings can be converted to halftone dot size using a conversion table such as Table 7.2 in Adams et al. (1996).) If the actual halftone dot sizes on the film or plate do not reasonably match those specified on the target, the output device must be calibrated and a new film or plate made before continuing the fingerprinting test.

If the target was output to film on an imagesetter, the film must be stripped and plated. When making a plate for a fingerprinting test, it is imperative that proper draw-down is achieved in the vacuum frame to prevent dot gain caused by halation. The vacuum gauge must read at least 22.5" and Newton Rings must be in evidence before the plate is exposed. It is

also important that the exposure time be set according to the plate manufacturer's instructions. A transparent platemaker's gray scale or an UGRA scale should be exposed on the plate along with the fingerprinting target to be certain that the plate is properly exposed. After the plate has been processed, it is wise to use a reflection densitometer or dot meter to be sure that little or no dot gain has occurred during platemaking.

Before printing the fingerprinting target on a specified press, it is important to make sure the machine is properly adjusted. For example, on an offset-lithographic press these four press adjustments must be carefully set according to the press manufacturer's instructions: 1) ink-form to plate pressure(s); 2) dampener-form to plate pressure(s); 3) plate to blanket pressure; and 4) blanket to impression pressure. The inking and dampening systems must be set so that an even coverage of an attainable ink density is printed. Other printing processes require different adjustments. In flexography, impression pressure is most critical (Foundation of Flexographic Technical Association, 1991). In screen printing, squeegee shape, pressure, and angle impact dot gain. In addition, off-contact printing helps prevent the substrate from sticking to the screen, a source of dot gain (Adams et al., 1996). The solid black line at the bottom of the form can be used by the press operator to check ink density and coverage.

Once the press has been properly adjusted, the target should then be printed on samples of substrates ordinarily used in the facility. Then, a representative press sheet printed on each type of substrate must be carefully inspected using a 20× or stronger magnifier. The smallest cleanly printed highlight and largest cleanly printed shadow dots in the test pattern representing each lpi should be circled. These dot sizes should be used as targets whenever a grayscale image is being prepared for the specific press, substrate, and lpi represented by the fingerprinting target. For example, on an offset-lithographic press fingerprinting test on uncoated paper, the smallest attainable highlight dot might be 2% using a 65 lpi screen, but 10% using a 133 lpi screen. If a halftone is to be made at 133 lpi using



Figure 2



Figure 3



Figure 4

this particular press and substrate, a 10% dot should be specified for the highlight.

The actual size of the 50% dot patch in each test pattern should be measured with a dot area

meter or reflection densitometer and written on the target. For example, the 50% dot patch in the 65 lpi test pattern might measure 70%—the 50% dots have grown in size to appear to be 70% dots. This represents 20% dot gain. To compensate for this dot gain whenever a 65 lpi screen is specified, any area of the grayscale image that measures 70% must be decreased to 50% using Photoshop. When the image is printed on the press, dot gain will cause the 50% dots to become enlarged to measure 70%. In this way, the printed reproduction will more closely match the original gray scale image compared to a printed reproduction that has had no dot gain compensation applied.

Using Adobe Photoshop to Match a Grayscale Image to a Particular Fingerprint

Photoshop has three tools that are very useful in matching a grayscale image to a particular fingerprint. These include the Auto Levels command, the Curves dialog box, and the Duotone Curves dialog box. To illustrate the use of these tools, the procedure used to transform the printed halftone illustrated in Figure 2 into the more pleasing halftone in Figure 4 is given below.

The halftone in Figure 2 began as an RGB color image saved on a Kodak PhotoCD. The original image

was opened in Photoshop and converted to a grayscale image using the Mode submenu of the Image menu. In addition, the resolution of the original image was changed to 300 ppi, which is the appropriate resolution for a 150 lpi halftone. Figure 2 is a halftone made directly from that file with no correction applied.

Figure 3 has had the Auto Levels command applied. The Auto Levels command is accessed by choosing Adjust, then Auto Levels, from the Image menu. This command automatically places a 0% halftone dot in the whitest highlight and a 100% halftone dot in the blackest shadow. (Note: If the Auto Levels command does not position a 0% dot in the highlights and a 100% dot in the shadows, the Preferences file is not set at its default settings. To reset the defaults, the Photoshop Preferences file, found in the Preferences folder within the System folder, can be erased. The next time Photoshop is launched, a new Preferences file, containing all the default settings, will automatically be created.) The Auto Levels command automatically expands the copy density range of the grayscale image to its maximum. However, the copy density range must be altered to match the achievable printed density range. The image must also be altered to compensate for dot gain.

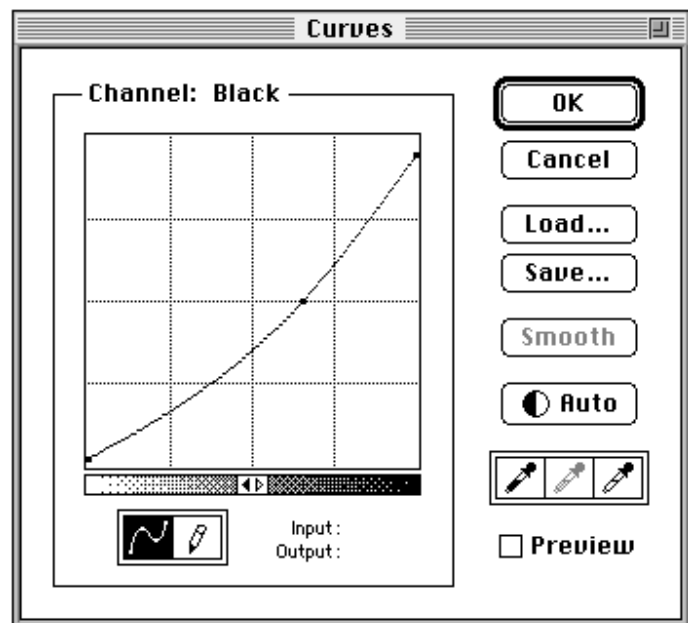


Figure 5

When this paper was written, the author did not have access to the actual fingerprinting data for the press/substrate combination that was ultimately used to print this journal. However, previous journals had been printed on coated paper using sheetfed offset-lithography, so the maximum shadow and minimum highlight dot sizes were derived from Table 1. In particular, the following data were used: 150 lpi screen, 2% minimum highlight dot size, and 95% maximum shadow dot size. Table 2 was used to derive the typical dot gain for sheetfed offset lithography on coated paper—15%. Had actual fingerprinting data been used, the printed reproduction in Figure 4 would look better than it actually does.

Compressing copy density range and accommodating dot gain is best done using the Curves dialog box (accessed by choosing Adjust, then Curves, from the Image menu). Three adjustments must be made to the curve using the Curves dialog box: 1) transforming 0% highlight dots into 2% dots; 2) changing 100% shadow dots into 95% dots; and 3) compensating for the predicted 15% dot gain by making 65% dots into 50% dots. Figure 4 is a halftone that has had those changes applied. Figure 5 illustrates the completed Curves dialog box used to affect the changes. To set the highlight dot size, drag the lowest point of the curve up until the Input field reads 0% and the Output field reads 2%. Similarly, the shadow is set by dragging the highest point of

the curve down until the Input field reads 100% and the Output field reads 95%. To compensate for the anticipated 15% dot gain, click anywhere on the middle of the curve and drag until the Input field reads 65% and the Output field reads 50%. Clicking OK closes the dialog box and applies the changes to the image.

If grayscale images will often be prepared for reproduction using the same fingerprinting data, it is best to save the curve so that it can be used again in the future. Clicking the Save button on the Curves dialog box causes another dialog box to be displayed so that the curve can be named and saved in an appropriate place. Later, it is simple to reload the curve by clicking Load to display a dialog box that is used to locate and open the chosen curve. The settings in a loaded curve are automatically applied to the image when the OK button is used to close the Curves dialog box.

The Duotone Curve dialog box is an alternative method for preparing curves. The Duotone Curve dialog box can be used to write curves without actually transforming a grayscale image into a duotone. This dialog box is accessed by displaying a grayscale image on the screen and choosing Duotone from the Mode submenu of the Image menu. The Duotone Options dialog box then appears. After Monotone is chosen from the Type menu and the curve next to Ink 1 is clicked, the Duotone Curve dialog box opens. The size of the smallest printable

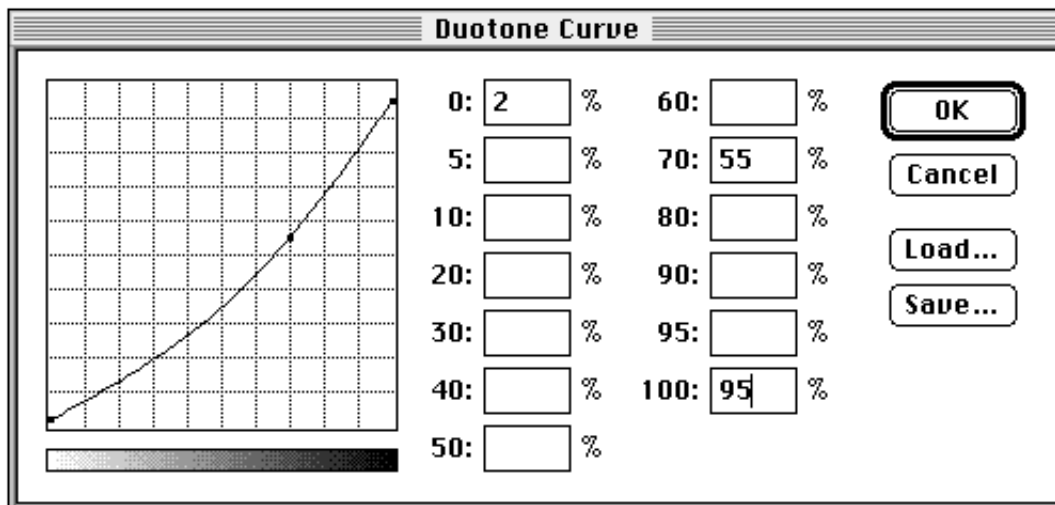


Figure 6

highlight dot (2% in this example) should be entered in the 0% field, type. Similarly, the size of the largest printable shadow dot (95%) should be entered in the 100% field. To compensate for dot gain, an appropriate value must be entered in a midtone dot field. In this example, 15% dot gain is anticipated. Because there is no 65% field in the dialog box, 55% was entered into the 70% field—this value is close enough to transform a 65% dot into a 50% dot. Figure 6 illustrates the completed Duotone Curve dialog box. Once the data has been entered, it should be saved by clicking the Save button. The curve should be appropriately named and saved. Once the curve is saved, the Duotone Curve dialog box is closed by clicking OK. Then, the Duotone Options dialog box closed without transforming the grayscale image into a duotone by clicking the Cancel button.

To apply a curve saved in the Duotone Curve dialog box to a grayscale image, Auto Levels should first be used set the highlight to 0% and the shadow to 100%. Then, the Curves dialog box should be opened and the saved curve loaded. The curve settings will automatically be applied to the grayscale image when OK is clicked to close the Curves dialog box.

Summary

The achievable printed density range of printed halftones is almost always smaller than the copy density range of original continuous tone photographs due to attributes of the ink, the substrate, and the printing press. To produce the best possible reproduction of any continuous tone photograph, the copy density range of the original must be compressed to match the achievable printed density range and a compensation made for dot gain. To determine the achievable printed density range a printing press can produce on a given substrate with a given ink, a series of tests must be run to ascertain the unique fingerprint of the press. The fingerprint of a press impacts the minimum and maximum halftone dots sizes that can be produced as well as evident dot gain. To obtain data necessary

to adequately alter original continuous tone images to match the fingerprint of a particular press, a test target, consisting of patches of halftone dots ranging from 1–10%, 50%, and 80–100% dots, should be printed on each commonly used substrate using each halftone lpi that is normally used on a given printing press. Careful examination of the printed targets will provide the minimum and maximum halftone dots sizes that are possible using the particular press/substrate combination. Measuring the actual printed size of the 50% dot area using a dot meter will indicate the percent of dot gain caused by the press.

Once a press has been tested, the minimum and maximum halftone dot sizes and dot gain information can be used in Photoshop to adjust the copy density range of the original to match the achievable printed density range of the printing press/substrate combination. The whitest area of the original is assigned the smallest printable halftone dot size, while the largest printable halftone dot size is assigned to the blackest area of the photograph. The dot gain percent is used to decrease the darkness of the midtone areas. In Photoshop, these adjustments can be made using either the Curves dialog box or the Duotone Curve dialog box.

Notes

- i Data in this table derived from Kagy and Adams (1983), Foundation of Flexographic Technical Association (1991), Gravure Association of America (1991), and Posters, Inc.
- ii An exception is Flexography, which tends to gain more in the highlights than in the midtones (Foundation of Flexographic Technical Association, 1991).
- iii Data in this table derived from Blatner and Fraser (1996), Flexographic Technical Association (1991), Margulis (1995), and Beach (1992).

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Using Photoshop for Color Demonstration

by Bob Chung

Abstract

Photoshop features, such as layers and channels, are used to demonstrate how concepts of color and color reproduction can be taught. Color demonstrations include visible spectrum generation, gray scale creation, additive color mixing, subtractive color mixing, color separation, process color printing, gray balance, and moiré pattern. A color version of this article in PDF format is available from the author's www site at <http://www.rit.edu/~rycprr/>.

Introduction

When it comes to digital color prepress imaging, Adobe Photoshop is used just about everywhere. There are technical conferences and video tape series just on how to use Photoshop effectively as a prepress production tool. For graphic arts teachers and trainers, it makes sense to use Photoshop as a tool to teach both the production techniques of pixel/color editing and the concepts of tone and color reproduction.

This article documents a series of tone and color demonstrations regarding color theory with the use of Photoshop. All the illustrations in this article are reproduced in black-and-white; the reader is encouraged to access a PDF version of this paper in color from the author's www site at <http://www.rit.edu/~rycprr/>.

This document begins by explaining how to create a spectrum, and practical uses of the spectrum are demonstrated. The next section explains how gray scales are created and may be used to study tone reproduction. The article then shows how to create the additive color mixing demonstration. This part of

the demonstration conveys the concept of color separation and how color television works. Lastly comes a discussion of subtractive color mixing, and an explanation of process color printing, gray balance, and moiré pattern.

Photoshop Preparation

This article was written based on the author's experiences in using version 3.0.4 of Adobe Photoshop running on a Macintosh computer. It assumes that the reader knows the basics of Mac operations and Photoshop. To start out, set your color monitor to thousands or millions of colors via the Mac Control Panels. Also, check the box, 'Color channels in color' in Photoshop's Preferences/General settings/Display dialog box.

Spectrum Demonstration

Normally, we need a prism and a slide projector in a darkened room to show that white light is composed of energies of different wavelengths. To do this with Photoshop, follow the steps outlined below.

1. Open a new file and set the image size—e.g., 5" wide × 4" long. Choose RGB mode and 72 ppi resolution (Figure 1a) with a black background. The black background is to simulate a darkened room where there is no energy.
2. Set the foreground color to solid blue color, (255 digital value) and the background color to solid red color (Figure 1b).
3. Use the gradient tool to draw a line from left to right with the tool specified as shown in Figure 1c. Pay attention to the style and

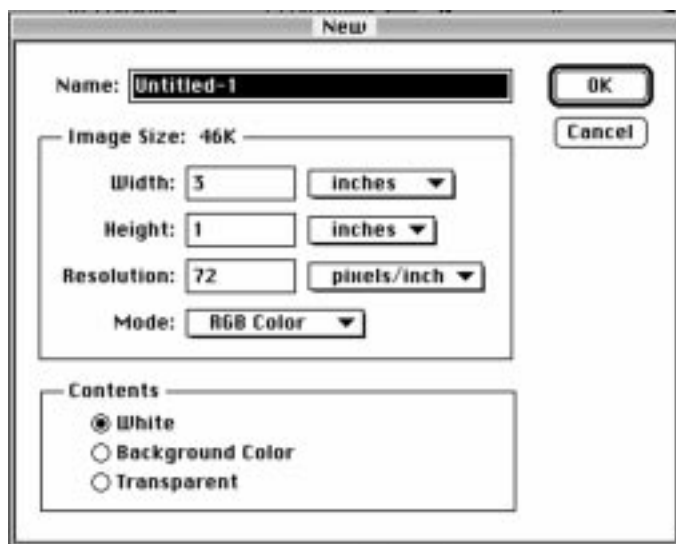


Figure 1a. Open a new file in Photoshop.

midpoint settings. The result is a spectrum in the correct orientation (Figure 1d).

4. There are two places the spectrum may be improved. First is the alignment between the wavelength and the color it represents. For example, the wavelength of 580 nm should coincide with yellow. This can be achieved by experimenting with the starting and ending points when using the gradient tool. The second improvement is the darkening of either side of the spectrum. To accomplish it, use layers and the gradient tool.

- a) Go to Windows/Palettes and Show Layers. Add a new layer and name the layer 'spectrum left'. When naming the layer, set opacity to '100' and mode to 'Darken.'
- b) Set the foreground color to solid

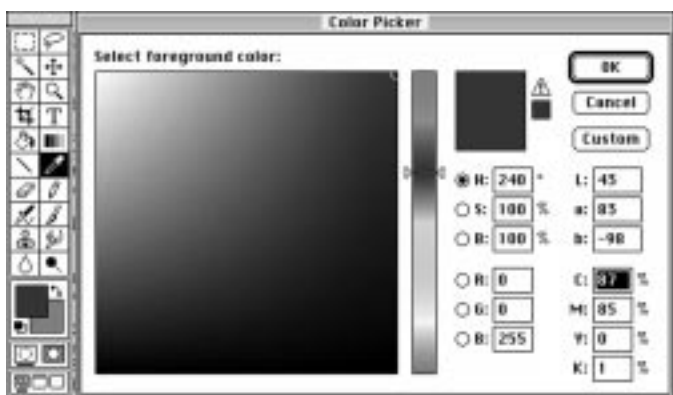


Figure 1b. Set foreground and background colors.

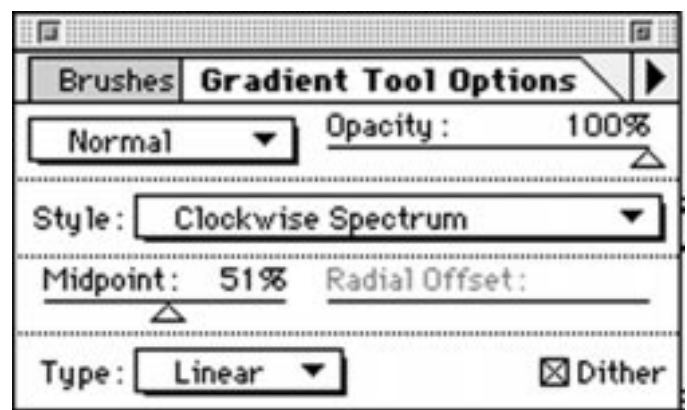


Figure 1c. Gradient tool options.

black (255 digital value), and the background color to white.

- c) Use the gradient tool to draw a line from the far left to one-third of the width and you will see the darkening effect on the left-hand-side of the spectrum. In the same manner, darken the right-hand-side of the spectrum.



Figure 1d. The visible spectrum.

5. Once you are satisfied with the appearance of the spectrum, you should flatten all layers and save it as a PICT file.

The primary use of the spectrum is to show that white light is made up of a range of wavelengths as we would see in a rainbow. Broadly speaking, white light is made up of a red portion (long wavelength),

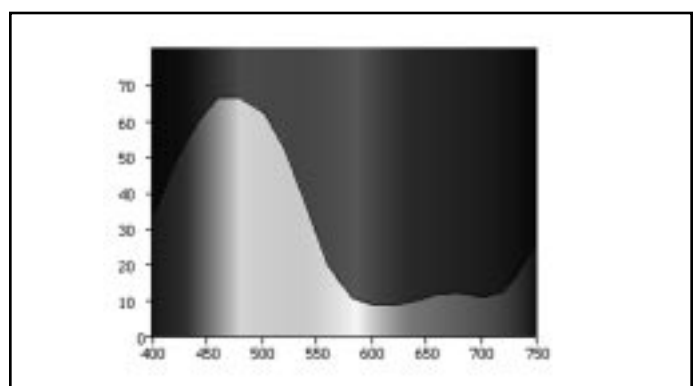


Figure 1e. Spectral reflectance curve of a cyan ink absorbing the long-wavelength portion of the spectrum.

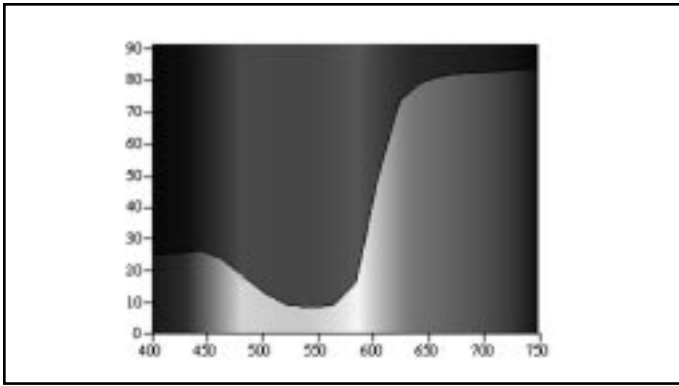


Figure 1f. Spectral reflectance curve of a magenta ink absorbing the medium-wavelength portion of the spectrum.

a green portion (medium wavelength), and a blue portion (short wavelength) of the spectrum.

The spectrum may be used as the background for a number of graphs relating to wavelength data. For example, we can show how a process ink (cyan, magenta, or yellow) absorbs and reflects certain portions of the spectrum with its spectral reflectance curve (Figures 1e, 1f, and 1g).

Gray Scale Demonstration

A gray scale is a systematic sampling of various tones in an image. By including a gray scale with an original in the reproduction process, we can study the tonal relationship between the original and its reproduction. To create a digital gray scale in Photoshop, follow the steps listed below:

1. Open a new file and set the image size, e.g., 4" wide $\times$ 1" long. Choose gray scale mode and set the resolution (ppi) at twice the screen ruling. Select a white background.

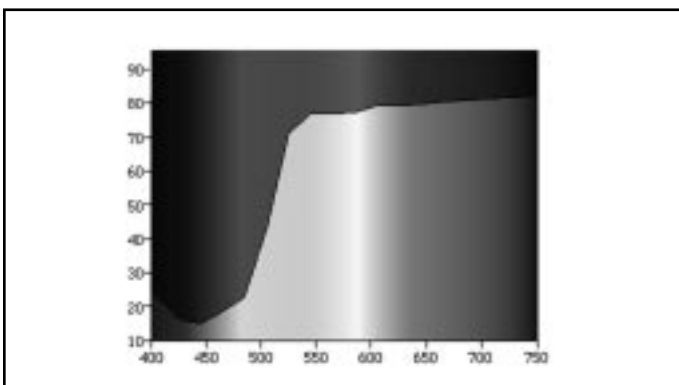


Figure 1g. Spectral reflectance curve of a yellow ink absorbing the short-wavelength portion of the spectrum.

2. Set the foreground color and the background color to its default black and white, and then switch the two so that foreground is white.
3. Use the gradient tool to draw a line from left to right. The result is a gradation from white to black (Figure 2, top).
4. Use Image/Map/Posterize to separate the gradation to, say, 10 steps. Now, what we have is a 10-step gray scale (Figure 2, middle).

The following steps describe a simple approach to convert the appearance of a continuous-tone gray scale to halftone.

1. Change the gray scale mode to bit map mode.
2. Set the output resolution (ppi) and halftone screen ruling (lpi). In order to achieve a very coarse halftone (Figure 2, bottom), set the resolution to 72 ppi and halftone screen ruling to 9 lpi.

Additive Color Mixing Demonstration

To physically demonstrate the principles of additive color mixing, we need three slide projectors stacked up in a rack to separately project a red light, a green light, and a blue light in a darkened room. By manipulating the three lights, we can show how lights behave additively with respect to human color perception. To demonstrate this with Photoshop, the 'Layers' feature is used. The following is what you need to do:

1. Open a new file and set the dimensions to 5"

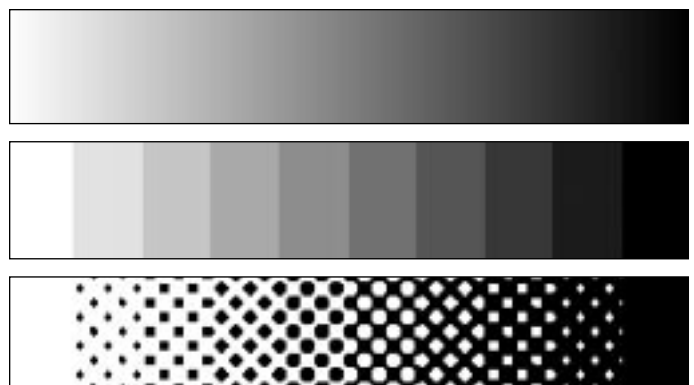


Figure 2. (top) a gradation from black to white; (middle) a 10-step gray scale; (bottom) a coarse halftone scale.

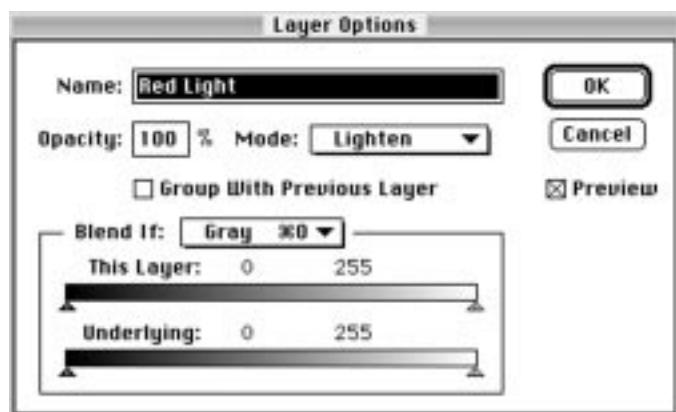


Figure 3a. Naming a new layer as the red light.

- × 5". Choose RGB mode at 72 ppi as before. Fill the entire image area with black.
2. Go to Windows/Palettes and Show Layers. Add a new layer and name it 'Red light.' When naming the layer, set the opacity to '100' and the mode to 'Lighten' (Figure 3a). Now the original file is known as background.
3. By highlighting the 'Red light' layer (Figure 3b), draw a circle with 1" diameter and fill the circle with a bright red color (255 digital value).
4. Add two more layers in the same manner and name them 'Green light' layer and the 'Blue light' layer.
5. When a layer is highlighted, you can move the circle around with the move tool. And by turning all three layers and the background on, you will see the effect of additive color

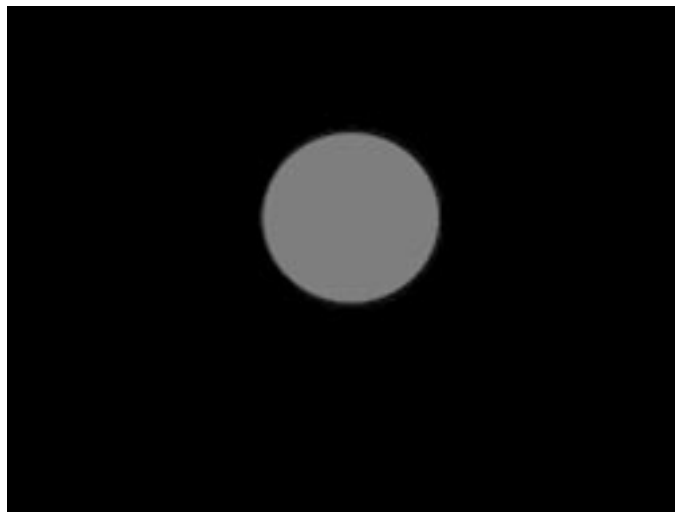


Figure 3b. Draw a circle and fill it with red.



Figure 3c. The additive color mixing principle.

mixing (Figure 3c).

The overlap of red and green lights yields yellow; the overlap of green and blue lights yields cyan; and the overlap of red and blue lights yields magenta. Since spectral energies are additive, the overlap of all three lights produces white.

An important application of the additive color mixing principle is color separation. The fact that red, green, and blue filters only pass one-third of the spectral energy gives us the ability to separate every pixel in an original into its respective red, green, and blue separation records (Figure 3d). To do this, we first open a TIFF/RGB image in Photoshop. By selecting 'Show Channels' and clicking the 'eye' to turn on or off each channel, we can appreciate the effect of additive color mixing.



Figure 3d. Color image reproduction (upper left) by means of the additive color primaries, RGB.

The other important application of the additive color mixing principle is additive color reproduction, or how color television works. Examine the face of a color monitor with a loupe. Here, we can see how colors are reproduced with various amounts of red, green, and blue lights very closely interlaced together.

Subtractive Color Mixing Demonstration

Images printed using process color, such as magazine ads, are examples of subtractive color mixing. But the evidence may not be as effective as an overlay-type color proof, like Color Key, when placed on top of a transparency viewer for demonstration purposes.

Procedures similar to those used in the additive color mixing demonstration apply when simulating subtractive color mixing with Photoshop. Here, the three layers are named as 'Cyan ink', 'Magenta ink', and 'Yellow ink.' Three exceptions are that:

1. the file should be in CMYK mode;
2. the content should be set to white to represent white paper; and
3. the mode of each layer should be set to 'Darken'.

Figure 4a shows the effect of subtractive color mixing. Notice how red, green, and blue colors result by overlapping two of the three subtractive primaries. In addition, the darkest area (black) is where all three layers meet. Colorants remove energies, giving

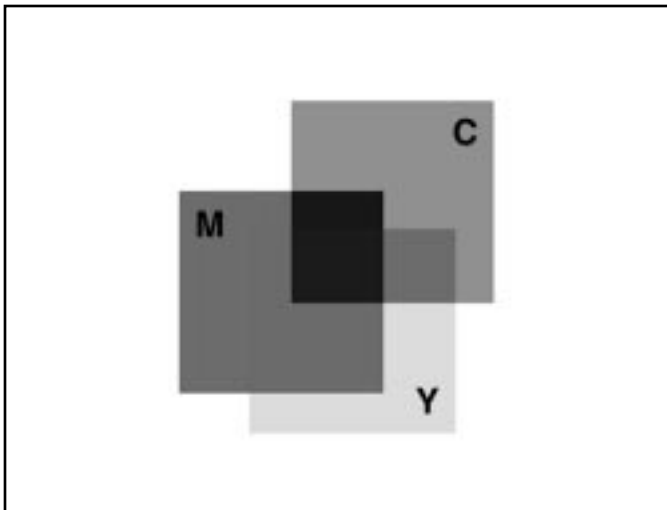


Figure 4a. The subtractive color mixing principle.

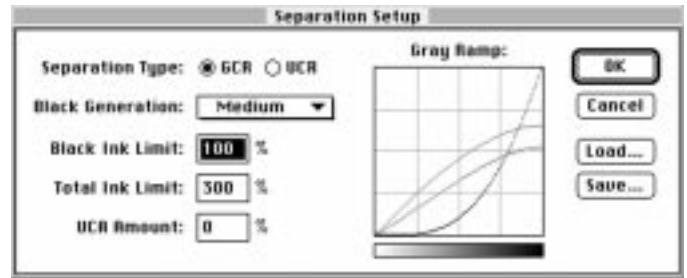


Figure 4b. Photoshop separation setup dialog box.

meaning to the word “subtractive” in subtractive color mixing.

An immediate application of subtractive color mixing is to show how color reproduction results by printing cyan, magenta, yellow, and black inks on white paper. To do this, we first open a TIFF/RGB image in Photoshop. We then set appropriate UCR, black ink limit, and TAC values in the 'Separation Setup' dialog box (Figure 4b) before changing the mode to CMYK. By selecting 'Show Channels' and clicking the 'eye' to turn on or off each channel, we can examine the effect of subtractive color mixing (Figure 4c).

Gray Balance Demonstration

Let's take the subtractive color mixing concept further and think about how the gray balance concept may be demonstrated with Photoshop. Follow the process outlined below.

1. Prepare a CMYK file with a white background.

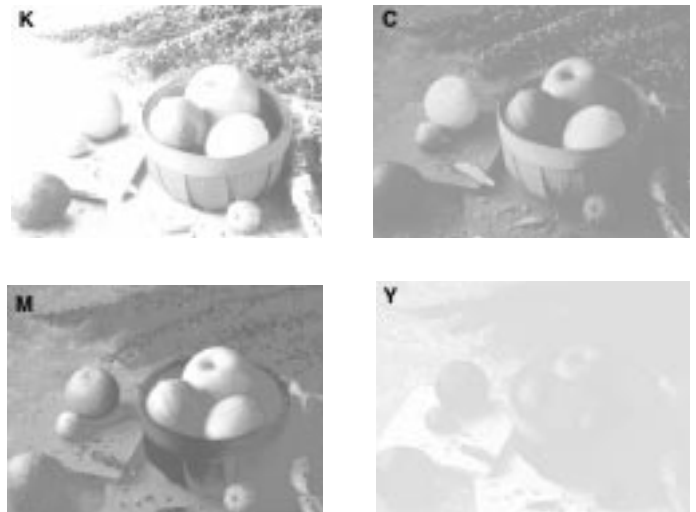


Figure 4c. Color image reproduction by means of mixing the subtractive color primaries, KCMY.

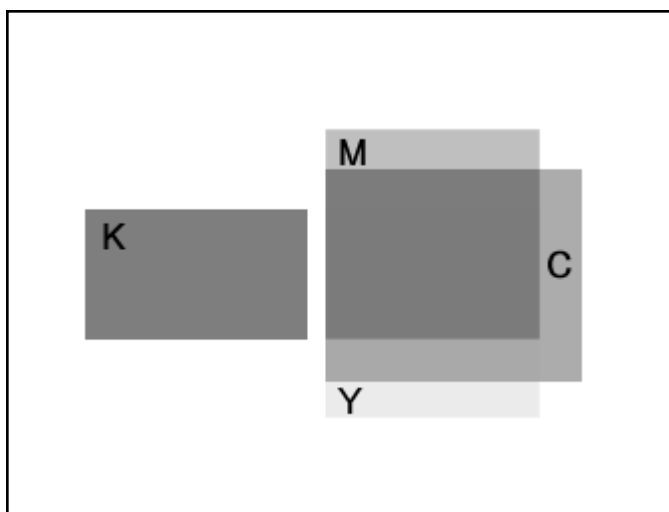


Figure 5a. CMY adjustable patch and a black tint patch.

2. Add four layers, i.e., Cyan ink, Magenta ink, Yellow ink, and Neutral.
3. Set up two fields. One should contain neutral only, while the other field should contain superimposed patches of C, M, and Y layers (Figure 5a).
4. Set GCR to none, black limit to zero, and TAC to 300 in the Separation Setup.

By highlighting the black tint layer, which is a field by itself, we can change the lightness or darkness of the black patch with the opacity slider (Figure 5b).

Now the challenge is to set the values for C, M, and Y with their respective sliders so that the three-color overlap matches that of the neutral patch. This demonstration is highly interactive and can be repeated at different black intensities by different students.

Moiré and Rosette Demonstration

In color printing, lighter tones of any color, including grays, are made from combinations of CMYK halftone dots. When arbitrarily overlapping two or more periodic (conventional) halftone

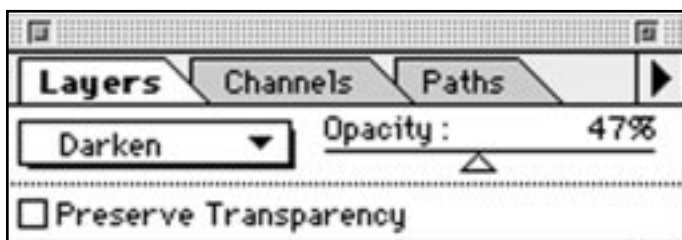


Figure 5b. Adjusting the gray with the opacity slider.



Figure 6a. Moiré pattern as the result of re-screening.

patterns together, an interference pattern will become evident (Figure 6a). This visually annoying and objectionable pattern is called moiré.

To demonstrate a moiré pattern, you need two pieces of halftone tint. By overlapping and rotating one halftone film over the other, the moiré effect can be seen. When two halftone screen angles differ by 30° the moiré pattern becomes least noticeable. This moiré-free pattern is referred to as a “rosette.”

To demonstrate moiré and rosette patterns in Photoshop, follow these steps.

1. Create a gray scale file with an image size of $2" \times 2"$ at the resolution of 100 ppi. Assign the entire image with, say, a 30% black tint.
2. Through mode change, convert the gray scale to bit map/halftone. It is a good idea to keep the halftone screen ruling very low—e.g., 5 lpi (Figure 6b).
3. Through mode change again, convert the bit map image back to gray scale. This makes the layer option possible.
4. Add a layer and place various angle indicators—e.g., 0, 15, 45, 75, and 90 degrees—with the line tool.

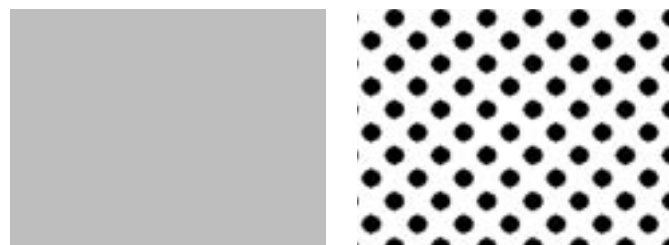


Figure 6b. (left) a gray tint; (right) a coarse halftone tint.

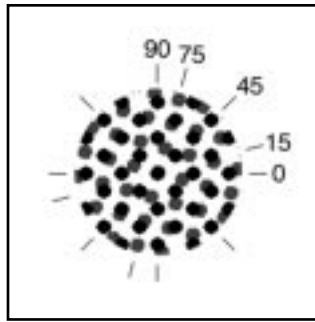
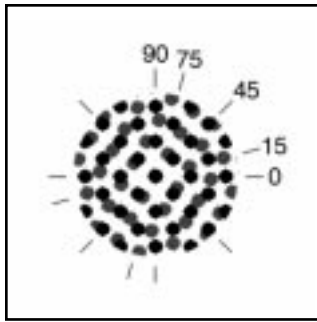


Figure 6c. (left) moiré pattern; (right) rosette pattern simulated in black-and-white duotone.

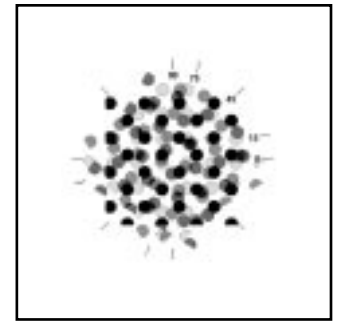
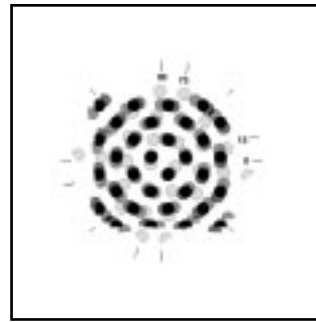


Figure 6d. (left) moiré pattern; (right) rosette pattern simulated in CMY layers.

5. Add another layer and copy the halftone pattern to the layer. Change the opacity to, say, 75%, so that there are visual differences between the background halftone and the layer halftone.
6. With the layer halftone activated, use the marquee tool to select an area, then go to image/rotate/free rotation. You can click and drag a corner of the box and see the effect of moiré or rosette patterns (Figure 6c).
7. By converting the gray scale file to the RGB mode, and by adding additional layers and changing halftones into CMY colors, you can simulate moiré and rosette patterns in process color (Figure 6d).

On-Screen Documentation

You may find a presentation program like Microsoft PowerPoint handy in capturing your work for future uses. While there are a number of file formats used in digital imaging, PowerPoint only renders PICT images well. Files containing layers can only be saved in the Photoshop format. To convert

the Photoshop file to PICT file, you need to 'flatten' the layers before you can save it. In some cases, the PICT file format is not available if a file is in the CMYK mode. Make sure that the CMYK file is converted to RGB mode before you save it as a PICT file. In addition, a control panel device, called Flash-It, is very useful in capturing a section of the screen and saving it as a PICT file.

Conclusion

Photoshop has become the default image editing software in the graphic arts industry and academic communities. Therefore, it makes sense to use Photoshop to demonstrate color. Besides, it is fun and is quite interactive from both a teaching and a learning point of view. The author has been teaching color and its reproduction for many years. He relies on many teaching aids such as slides, filters, light sources, and three projectors in a rack to do color demonstrations. While no single teaching aid can perform all color demonstrations, many of these demonstrations can be created, like virtual reality, with the use of Photoshop.

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Larry L Bradshaw is an assistant professor in the Department of Industrial Education and Technology at Iowa State University. He has taught graphic communications for several years, specializing in various printing techniques. He was a Fulbright-Hayes scholar to Cyprus in 1991, where he worked within the Technical Education Divisions and helped set up printing facilities and performed needs assessments for graphic communications education throughout the country.



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Robert Chung has been a faculty member in the School of Printing Management and Sciences at Rochester Institute of Technology since 1980. He holds the rank of Professor and teaches courses in color perception and measurement, tone and color analysis, and quality control in the graphic arts.

Bob is active in a number of professional associations. He served on the board of the International Graphic Arts Education Association (IGAEA), the Technical Association of the Graphic Arts (TAGA), and the Inter-Society for Color Council (ISCC). He was the recipient of the 1991 GATF's Education Award of Excellence, and the 1997 Gravure Education Foundation Exchange Professor. Bob also holds membership in Phi Kappa Phi, American Society for Quality Control (ASQC), and Graphic Arts Technical Foundation (GATF).



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Dr. De Leon is an assistant professor in the Department of Technology at Southwest Texas State University. His teaching duties include computer aided drafting/design, industrial safety, and quality control. He worked for ten years in the steel industry before entering academia. In addition, Dr. De Leon is active in developing and teaching industrial training curricula for local companies.



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Further work shows (Jones, 1985)...
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