Visual Communications Journal

Spring 2021 | Volume 57 | Number 1

Ali Gutc | Pittsburg State University

2019 Gutenberg Photography Winner | Digitally Altered Composite | College and University Division

VISUAL COMMUNICATIONS JOURNAL

VCJ

VOLUME 57 NUMBER 1 SPRING 2021

GRAPHIC COMMUNICATIONS EDUCATION ASSOCIATION

Acknowledgements

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

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Reference Sources
The Visual Communications Journal can be found on EBSCOHost databases.
ISSN: Print: 0507-1658 Web: 2155-2428

GCEA Board of Directors

How Can Design Facilitate Sustainable Packaging?

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Abstract

In 2016, food packaging made up an overwhelming 92 percent of "3.4 trillion units of global retail packaging" (SAP, 2019, para. 2). And unfortunately, much of that packaging contributes to the growing problems of unsustainable material usage and the generation of massive amounts of waste (SAP, 2019; Brucker, 2018). Through analyzing the environmental impact of packaging, exploring the different types of currently available sustainable packaging, and examining the influence of packaging design on product transportation, this paper seeks to demonstrate to graphic communication professionals how packaging design can improve product shipment as well as improve environmental sustainability. More specifically, this paper points out the impact that packaging design can have on an existing food product in terms of sustainable material usage and space optimization.

Problem Statement

Introduction

Professionals in the graphic communication field can make a positive impact on the natural world by placing sustainability at the core of their packaging design process (Lacy & Spindler, 2019). It is imperative that they strive to make a difference because Americans discard more than two million plastic bottles every hour, thus adding to the twenty-five trillion bits of plastic waste in the ocean (Brucker, 2018). Confronted by the detrimental impact of packaging on the environment and consumers' demand for more eco-friendly solutions, brands are now seeking ways to produce more sustainable packaging (Bird, 2018). However, with sustainable packaging development comes the challenge of employing more expensive and less readily available materials and dealing with uncontrollable factors such as the recycling process (Vella, 2018). With that said, incorporating sustainability into the design process will enable businesses to manufacture green packaging in a cost-effective manner (Vella, 2018). Designing with sustainability in mind allows producers to create more space-saving, lightweight, and efficient packaging with less material, resulting in less waste and operational costs (SAP, 2019).

Research Question

The goal of this study is to examine how sustainable design can facilitate the production of environmentally friendly packaging. The study will review the following question:

How can a sustainable approach to packaging design reduce unsustainable material usage while creating a more effective use the available pallet volume during transportation?

Significance of the Study

This study presents a method of examining the effects that sustainable packaging design has on the pallet space utilization and freight cost associated with product transportation. Through packaging redesign, this author examined which package design is the most effective at utilizing eco-friendly material and saving space during shipment. According to the EPA (n.d.), the transportation division is responsible for producing the highest percentage of emissions. The findings of sustainable design are therefore essential in formulating an efficient protective packaging solution to help companies be part of the fast-growing eco-friendly packaging trend and reduce greenhouse gas emission from transportation. These ideas are significant to students and professionals in the graphic communication field because they present a chance for tackling two pressing environmental and waste concerns at once.

Definition of Terms

The meaning and usage of the following terms in my study are explained below to increase the readability of this study:

Biodegradable is defined as able to promptly decompose and become part of the natural environment (City of Austin, 2017).

Compostable is described as able to promptly and safely decompose or transform into a component of fertilizer when given the appropriate composting conditions (City of Austin, 2017).

Eco-conscious is defined as being mindful about nature (Merriam-Webster, n.d).

E-commerce is defined as the online transaction of goods and services (Department for International Trade, 2018).

Packaging refers to containers of any material that preserves goods during all stages before consumption (Two Sides, n.d.).

Sustainable is defined as being derived from recycled materials, recyclable, biodegradable, compostable, non-hazardous, and having a minimal impact on the environment. Throughout this study, sustainable is used interchangeably with eco-friendly, green, and environmentally friendly (Harari, 2019).

Sustainable design is defined as the practice of designing in a way that does not negatively impact the environment and with consideration to natural resources (Elmansy, 2014).

Literature Review

To build a foundation for the testing phase of this paper, this author analyzed and compared information related to sustainable packaging among several sources. The information derived from my examination of the sources is organized into subsections to best present how they relate to my research question.

Is There a Need for Sustainable Packaging?

According to Lacy and Spindler (2019), the underwhelming focus on designing green packaging is leading to the production of many nonrenewable and disposable packaging. This type of production is especially worrisome when the number of packages produced in 2016, as stated by SAP (2019), was over three million. Less than 15% of the world's plastic packaging recycled and approximately one-third of the packaging from landfills makes its way to the natural environment (Lacy and Spindler, 2019). In addition, while the volume of plastic packaging in 2017 multiplied by roughly 200 times as compared to 1950, the waste disposal system is not up to par and is "still widely underperforming" (Foschi & Bonoli, 2019, p. 1).

In addition, over 160 billion parcels are shipped every year in America (Bird, 2018). And with the rise of e-commerce, many products are shipped together with air cushions in oversized cartons to minimize the damage during transportation, which is "effective, but wasteful" (Bird, 2018, para. 5).

How is Sustainable Packaging Being Approached?

As consumers become more mindful about purchasing green products and supporting eco-conscious companies, manufacturers are pushing to produce more eco-friendly packaging (Lacy & Spindler, 2019). One example is Proctor & Gamble's invention that turns recycled polypropylene into raw material for various types of packaging (Lacy & Spindler, 2019). Another example would be Limeloop's production of upcycled shipping containers from billboard banners that are reusable for up to "2000 times" (Bird, 2018, para. 8). That said, Lacy and Spindler (2019) recognized that gathering packages after consumption is a challenging and costly process for many companies.

Besides utilizing recycled materials, companies are also promoting the production of biodegradable packaging. Ecovative Design's compostable packaging, made from mushrooms, is being adopted by prominent corporations such as IKEA and Dell. In addition, Do Eat's edible and biodegradable packaging are exemplary models of this initiative (Lacy & Spindler, 2019). Compostable packaging can be made from either corn starch or recycled polythene (SAP, 2019). Paper is likewise a popular material for its "reusable, recyclable and biodegradable" nature (SAP, 2019, para. 15; Two Sides, 2018). According to Two Sides (2018), paper packaging is "the most recycled of all packaging materials" and is an excellent choice for "efficient logistic operations" (p. 3, p. 13).

In addition to incorporating eco-friendly materials, packaging manufacturers are also working on making more efficient packaging and using less material in the process (SAP, 2019). A good case in point is Danone Canada's redesign of their yogurt cups to be smaller and thinner but still efficient by using more durable material (SAP, 2019).

How Does Packaging Design Affect the Transportation of Goods?

According to Jimenez-Guerrero et al. (2015), Mercadona supermarket was able to fill more products on a single pallet, and therefore reduce the number of deliveries, by redesigning the shape of their products' packaging. This change in design allowed Mercadona to achieve more desirable logistics and optimize costs (Jimenez-Guerrero et al., 2015). If paper is chosen as the primary packaging material, the product will be light, space-saving, and easy to stack (Two Sides, 2018). As a result, a fully loaded truck can carry approximately "95% product and only 5% packaging" (Two Sides, 2018, p. 13). According to SAP (2019), lightweight packaging can also help decrease the cost of logistics. And most importantly, effective packaging helps to reduce the amount of food waste during transportation in industrialized countries to less than 5% (Two Sides, n.d.).

How Can the Sustainability of a Package be Improved from a Designer's Standpoint?

Fayne (2020) pointed out that "knowing what's available" is crucial in packaging development because a massive amount of the chosen material will be needed to meet consumers' demand. Fayne (2020) also advised designers to prioritize, meaning to fulfill a specific sustainable requirement rather than attempting to achieve everything at once. Since colored packaging improves the sorting process during the disposal of packages, he also noted that there is an increased demand for package design to indicate a package's material composition (Fayne, 2020).

To obtain more information on how a designer has improved the sustainability of packaging, this author reached out to Buckeye Corrugated, Inc (BCI). BCI provided an example of how transforming a Pretty Darn Quick (PDQ) tray with a static graphic blocker can increase the number of displays on a pallet, reduce the number of trucks needed for transportation, and reduce freight costs. Through their example, packaging redesign was shown to be an effective approach to improving the sustainability of a package.

Although the PDQ displays shown by BCI consist of only corrugated cardboard, PDQ displays for canned goods and other rigid packaging currently utilize a plastic shrink band to secure the products rather than a conventional perforated tray (Walmart, 2016). Plastic, however, is not as environmentally friendly compared to materials that are paper based, as previously mentioned (Two Sides, 2018).

Finally, foods such as legumes, fruit, and soup tend to be packaged in cylindrical cans. Kohlstedt (2016), notes that round packages have a packing factor that is 9% less than that of a cuboid can (Please see Figure 1.) Consequently, this author chose to answer the thesis question by redesigning both a product's packaging and its PDQ display.

Figure 1
Cylindrical cans (left) vs. cuboid cans (right)

Method

To experience the final 3D renderings produced for this study, please scan each QR code with your mobile device or visit the link shown at each step.

Materials

A cylindrical can of Swanson's Chicken Broth was redesigned as a cuboid can to obtain a packing factor higher than 91% (Kohlstedt, 2016). Additionally, the PDQ tray was modified so that the packaging for the shipment of Chicken Broth cans only uses corrugated cardboard to increase recyclability while maintaining the ease of opening and relatively low weight for efficient and cost-effective transportation (SAP, 2019; Two Sides, 2018). To further explain, a short straight tray, which is a type of tray primarily used for cans and can be used in conjunction with a plastic shrink band, was redesigned to remove the need for using plastic bands.

To ensure that the redesigned packages maintained their original qualifications, Walmart's "RRP and PDQ Display Standard Style Guideline" was used as a blueprint for the design process (Walmart, 2016). This blueprint assisted in making sure that the redesigned packages meet the PDQ display sizing requirements as well as all shipping and handling criteria (Walmart, 2016). With these specifications in mind, the cans and their labels were created using Adobe Illustrator and Dimensions while the PDQ trays were redesigned in ArtiosCAD, a software for structural packaging design.

Design Requirements

To compare the effectiveness of the original and redesigned product packaging, both packages were required to hold the same volume of liquid and be stacked on a full pallet that is 40 inches wide by 48 inches tall (Walmart, 2016). The number of cans on a single pallet was then measured for both original and redesigned product packages to indicate their efficiency in pallet space utilization. In addition, to assess the sustainability of the original and redesigned PDQ tray, this author noted the difference in the material utilized for the trays.

Procedure

First, the measurements of a can of Swanson's Chicken Broth were obtained and then used to calculate the can's volume. The diameter and height of a 14.5 oz can of the Chicken Broth were measured and recorded as 2.95 inches and 4.13 inches, respectively. This author then used these measurements to create a sketch of a cylindrical can as well as calculated the broth can's volume, which came out to be 28.3 cubic inches. Based on the original broth can's measurements, a sketch of a cuboid can with the length and height was produced the same dimensions as the cylindrical can's diameter and height.

Kohlstedt (2016) notes that a cuboid can with a 90 degrees corner maximizes the packing factor but sacrifices the ergonomic aspect and results in "weak points" along the edges (para. 4). To combat these issues, rounded corners with a radius of 0.5 inches were incorporated to make the can more comfortable to hold while also reducing the length of the edges. A formula for calculating a rounded rectangle's area to compute a length of 2.95 inches to ensure the same volume as the original for the cuboid can.

Next, rough sketches of both the cylindrical and cuboid cans with measurements were produced to make sure that the new design meets the volume requirements and to help with visualization when creating the can in Adobe Dimensions. Then, a rough sketch of both PDQ trays was produced using the appropriate dimensions. Before creating the 3D designs, the dimensions of the filled PDQ trays was calculated to make sure that they would fit on a full pallet to follow the Walmart's guidelines.

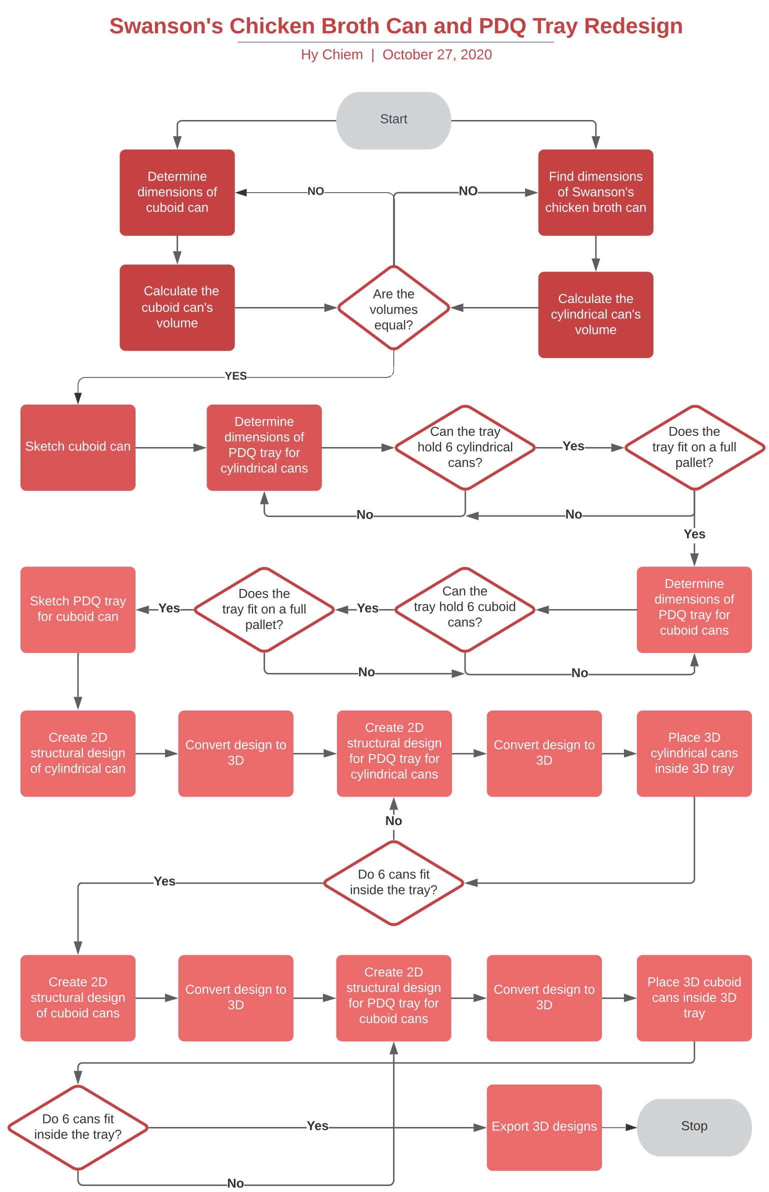
With the finalized sketches as a visual reference, this author created the 3D cuboid and cylindrical cans using Adobe Dimension. Labels for both cans were designed using Adobe Illustrator. In addition, a ring pull was added to the cuboid can design to improve the ease of opening of the product.

ArtiosCAD was used to design folded 3D PDQ trays to hold the cans. The PDQ tray for cuboid cans was designed as a rectangular box with a removable strip and two rounded rectangular shaped cutouts to remove the need for plastic wrap. The removable strip and cutouts ensure that the PDQ tray is quick and easy to open and be displayed per Walmart's guidelines (Walmart, 2016).

Next, the 3D cans were imported and the corresponding 3D PDQ design into a single Adobe Dimensions file to place the cans inside their tray. Lastly, the 3D models of the original and redesigned packages were exported in various set ups and presented as the final product for this study. A flowchart of the procedure can be seen in Figure 2.

Figure 2

Flowchart of the Swanson's Chicken Broth can redesign procedure



Results

3D Packaging Development

As a frame of reference, the existing Swanson's Chicken Broth can was recreated using Adobe Dimension. This recreation can be seen in 2D in Figure 3. An individual can use a phone's camera to capture QR code 2 to see a 3D representation of the can.

Figure 3
3D illustration of the original Swanson's Chicken Broth can

QR Code 1
3D illustration of the original Swanson's Chicken Broth can

Then, utilizing the sketches previously made, a new cuboid can was designed that holds the same volume of Swanson Chicken Broth as the original cylindrical can. This design can be seen in 2D in Figure 4. You can also use your phone's camera to capture QR code 2 to see a 3D representation of the can.

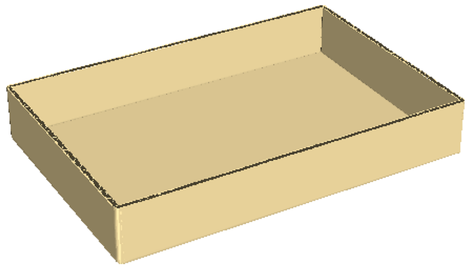
Figure 4
3D illustration of the redesigned cuboid can

QR Code 2
3D illustration of the redesigned cuboid can

Once the 3D cans' designs were completed, this author recreated the original Swanson chicken soup label and then created a duplicate of the label with some revision to fit the cuboid shape in Adobe Illustrator. These labels were then imported and placed onto the 3D can designs through Adobe Dimensions. The labels can be seen on the packages shown in Figures 3 and 4.

Subsequently, the 3D structural design of the PDQ trays was created for the original cylindrical cans and exported them as 3D PDFs in ArtiosCAD. This design can be seen in 2D in Figure 5. You can also use your phone's camera to capture QR code 3 to see a 3D representation of the PDQ tray.

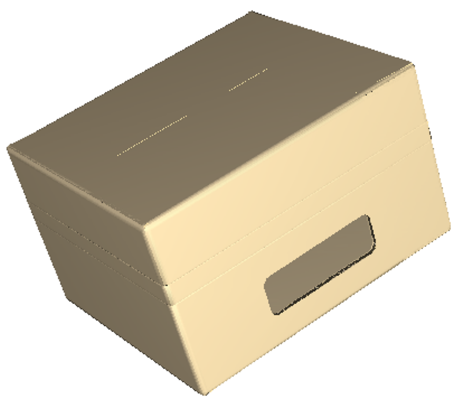
Figure 5
3D illustration of the PDQ tray for the original cans



QR Code 3
3D illustration of the PDQ tray for the original cans

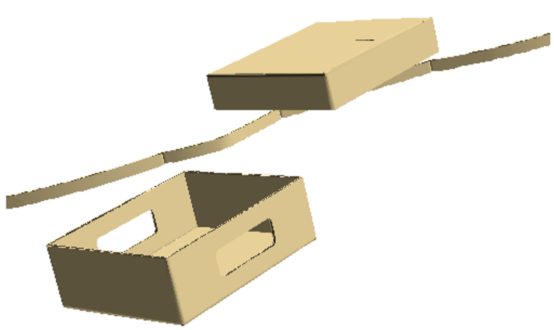
The PDQ tray for cuboid cans was designed as a rectangular box with a removable strip and two rounded rectangular shaped cutouts to remove the need for plastic wrap. Figure 6 shows the box intact and Figure 7 shows it opened. Note in that the removable strip is above the handholds so that the perforations will not tear when the carton is lifted. QR codes 4 and 5 provide 3D representations of the designs.

Figure 6
3D illustration of the closed PDQ tray for the cuboid cans



QR Code 4
3D illustration of the closed PDQ tray for the cuboid cans

Figure 7
3D illustration of the open PDQ tray for the cuboid cans



QR Code 5
3D illustration of the open PDQ tray for the cuboid cans

These PDFs were then converted into STL files using Adobe Photoshop so that they could be imported into Adobe Dimensions. With all the created assets, several PDFs depicting the cans and PDQ trays in different setups were produced. Note the wasted space between the cylindrical cans in Figure 8 has been reduced by the cuboid cans in Figure 9. QR codes 6 and 7 provide 3D representations of the designs.

Figure 8
3D illustration of six original cans inside their PDQ tray

QR Code 6
3D illustration of six original cans inside their PDQ tray

Figure 9
3D illustration of six cuboid cans inside their PDQ tray

QR Code 7
3D illustration of six cuboid cans inside their PDQ tray

The redesigned cuboid container results in more efficient shipping. A single layer of PDQ trays of cylindrical cans stacked on a pallet consists of 30 trays (5 ´ 6) as shown in Figure 10. However, the redesigned PDQ tray holding the cuboid cans, shown in Figure 11, proved to be more space efficient as it allows six more trays or 36 trays (6 ´ 6) per pallet layer.

Figure 10
2D illustration of one layer of PDQ trays for the original cans on a full pallet

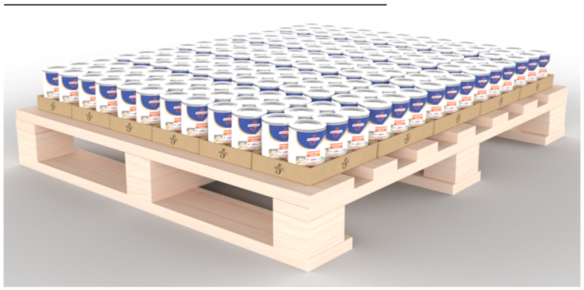
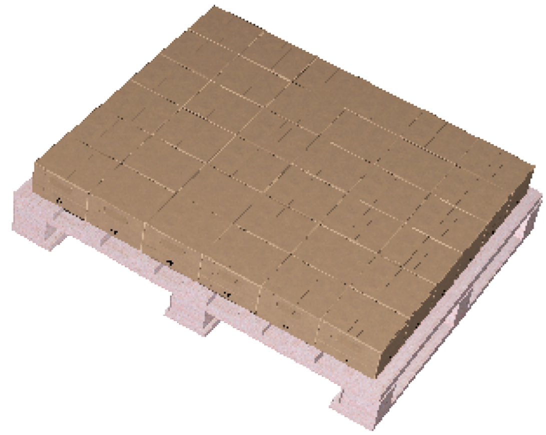


Figure 11
3D illustration of one layer of the PDQ trays for cuboid cans on a full pallet



As a result of this increased efficiency, when a pallet is fully loaded with nine layers of PDQ trays, the redesigned packaging would allow 54 more trays or 324 cans to be loaded.

Conclusions and Recommendations

From this study of Swanson's Chicken Broth packaging design, it was concluded that redesigning cylindrical cans as cuboid cans can help to reduce freight cost and transportation emissions as fewer trips are needed to transport the same number of products. Additionally, redesigning PDQ trays that use plastic shrink bands as a 100 percent corrugated cardboard PDQ tray with a tearaway strip can decrease the environmental impact of food packaging. The redesigned PDQ trays help to reduce plastic use while remaining quick and easy to disassemble and display.

For this reason, it is hopeful that graphic communication students recognize the significance of packaging design and strongly suggest that they to learn how to create 3D packaging designs. Likewise, it is recommended that professors develop projects related to packaging design to promote the learning of 3D and structural packaging designs. Lastly, this author would highly recommend that canned food manufacturers explore and carry out more extensive research on how packaging redesigning can be utilized to optimize their product shipment.

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Using ColorThink and Online Teaching

Robert Chung, Professor Emeritus
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Introduction

The author taught many years of color reproduction-related courses to college students in print media and graphic communication programs. He used to think that hands-on lab assignment was only possible in-person in laboratory settings. His recent online teaching experiences proved him wrong. This document describes a lab assignment, Using ColorThink, in an online course, administered by Wuhan University, in the summer of 2020. Due to the coronavirus pandemic, no one was on campus. All eleven students were spread out across many provinces in China. As an adjunct instructor, located in North America, the author was able to connect with his students via Zoom for synchronous communication and relied on WeChat and email for asynchronous communication.

Background

Printing-Process Control and Standardization was offered as a 4-week, 2-credit undergraduate professional elective course in the Wuhan University Summer School International Program. The lab assignment took place in the 4th week. Students learned colorimetry and ICC color management via video-taped lectures and chapter readings (Chung, 2020) in previous weeks. They Students understand that International Color Consortium (ICC) addresses color management at operating system's (OS) level. They recognize that characterized reference printing conditions (CRPC), the same as look-up-tables of ICC profiles, define the relationship between CMYK (input data) and printed color.

The ICC web site contains a wealth of up-to-date information, including ICC specifications, ISO-sanctioned and registered ICC profiles, including CRPC1~CRPC7. Students were directed to the ICC web site, www.color.org > ICC Profile Registry, to download two of the seven (CRPC1~CRPC7) ICC profiles. To introduce different hands-on experiences, CRPC1 and CRPC4 were assigned to a fraction of the class, CRPC2 and CRPC5 were assigned to the other fraction of the class, CRPC3 and CRPC6 were assigned to another fraction of the class, etc.

They were asked to study an instructional video, using Camtasia 3 screen-and-voice capturing software, introducing major features of the ColorThink Pro 3. In a nutshell, ColorThink Pro 3 can open ICC profiles, color images, and color lists, perform color conversions, display color-managed images and their differences, compute color differences, and many other color analysis functions.

Lab Procedure

Students attended Zoom meetings three times a week. During the sessions the instructor went over examples and answered questions before students began working on the lab assignment. Although students had good command of the English language, both English and Chinese were used in the classroom. The lab report, using the English only, was due two days later.

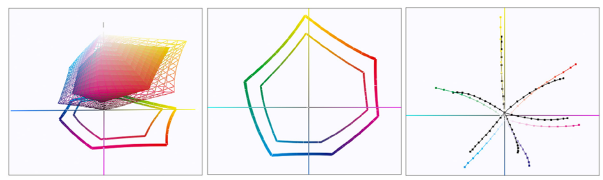
There were three lab objectives that covered basic and advanced concepts. The first lab objective was to analyze two of the seven CRPC profiles using ColorThink Pro 3 software. In other words, students were asked to compare two CMYK device gamut's in 3-D, 2-D, spider plot, and set up a data table to compare CIELAB values of CMYK solids, paper, and ΔE00 between them. Students were asked to discuss pros and cons of each graph. The second lab objective was to apply the assigned ICC profiles to students' own RGB images in RGB-to-CMYK color image reproduction workflows. In addition to simulating the visual difference of two sRGB-to-CMYK workflows, students were asked to show vector plots of custom sampled image pixels. The third lab objective was to assess the round-trip error of two CMYK ICC profiles. The legacy CMYK file, IT874_CMYK_1617.txt, were was provided as the start of a color worksheet. Students were asked to discuss the round-trip error, in terms of the 95th percentile ΔE00, as a baseline for determining color matching of Pantone colors using ICC-based color management workflows.

The author contacted CHROMiX, stated his intention, and asked for a one-month gratis license of the ColorThink Pro 3.0.5 (WIN) so that students could gain some hands-on experience. The process from obtaining the license to installing the software to students' PCs went smoothly. The author also found Idealliance's Guide to Print Production, Version 20.1 (2020) a valuable reference at www.idealliance.org.

Results and Discussions

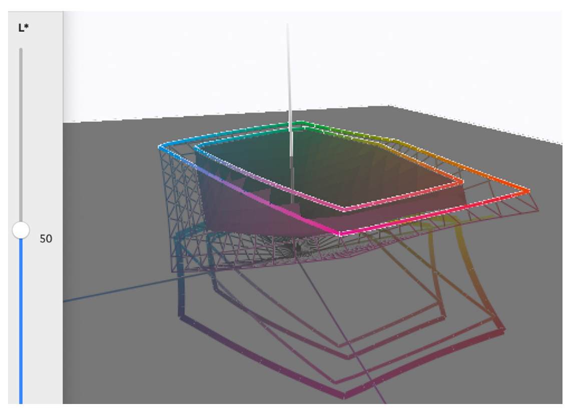
Figure 1 illustrates the comparison of two printers' color gamuts in 3-D (left), 2-D (center), and spider (right) plots. In this case, a student compared CRPC4 (the smaller gamut) and CRPC7 (the larger gamut). Other students compared CRPC1 and CRPC4, CRPC2 and CRPC5, and CRPC3 and CRPC6, respectively.

Figure 1
Gamut comparison between CRPC4 and CRPC7.



Everyone observed that the 3-D gamut plot is visual, comprehensive, but difficult to document in the report; the 2-D plot is brief, cursory, and can be deceiving because the third (L*) dimension is missing. However, the 3-D plot with an L* slicer, as shown in Figure 2, proves to be a useful feature to compare the gamut size at a constant (in this case, 50) L* plane.

Figure 2
3-D gamut with a L* slicer between CRPC4 and CRPC7.



While 2-D and 3-D plots emphasize gamut boundaries, the spider plot offers process control (solid coloration) insight. It compliments with the data table (Table 1) that provides CIELAB values of the white point and solid coloration. Color differences of the white point and solid coloration between CRPC4 and CRPC7 printing conditions are also shown.

Table 1
Solid coloration between CRPC4 and CRPC7.

	C100		M100		Y100		K100		Paper	
	CRPC4	CRPC7	CRPC4	CRPC7	CRPC4	CRPC7	CRPC4	CRPC7	CRPC4	CRPC7
L*	55	54	47	47	83	90	23	14	89	97
a*	-36	-42	66	78	-3	-4	1	0	0	1
b*	-38	-54	-3	-10	83	103	2	0	3	-4
ΔE_{00}	5.0		3.8		6.0		6.6		8.4	

The second lab objective, building two RGB-to-CMYK workflows using one's own pictorial color image, was more interesting than the first lab objective. Figure 3 is a visualization of the sRGB-to-CMYK3 (left) and the sRGB-to-CMYK6 (right) color image reproduction workflows under relative colorimetric rendering intent. This multi-hue, colorful image, from the author, worked well to illustrate the visual difference, i.e., CRPC3 (uncoated paper) shows limited colorfulness than CRPC6 (coated paper).

Figure 3
Visualization of sRGB-to-CMYK3 (left) and sRGB-to-CMYK6 (right) workflows.

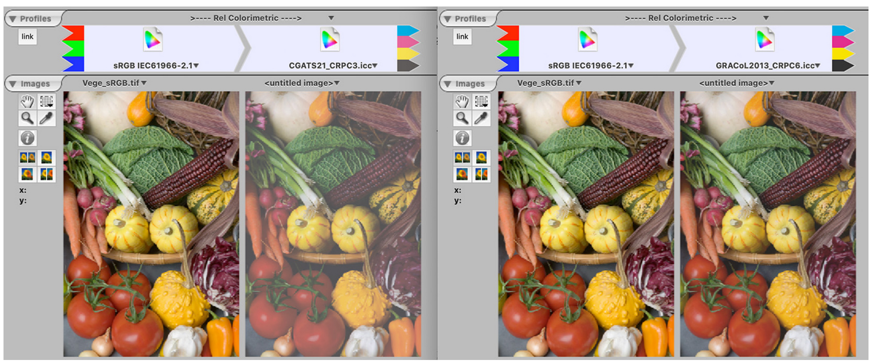


Figure 3 shows that when gamut compression is inevitable, a "dimmed" color results due to the loss in L* range (including the white point) and chroma. In this case, the CRPC3 reproduction (left) is dimmed more than the CRPC6 reproduction (right).

Figure 4
Vector plots of image pixels between sRGB and CRPC3 (left) and CRPC6 (right).

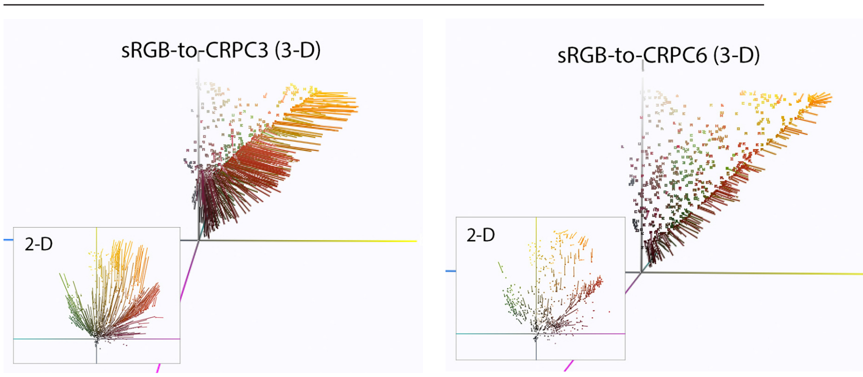
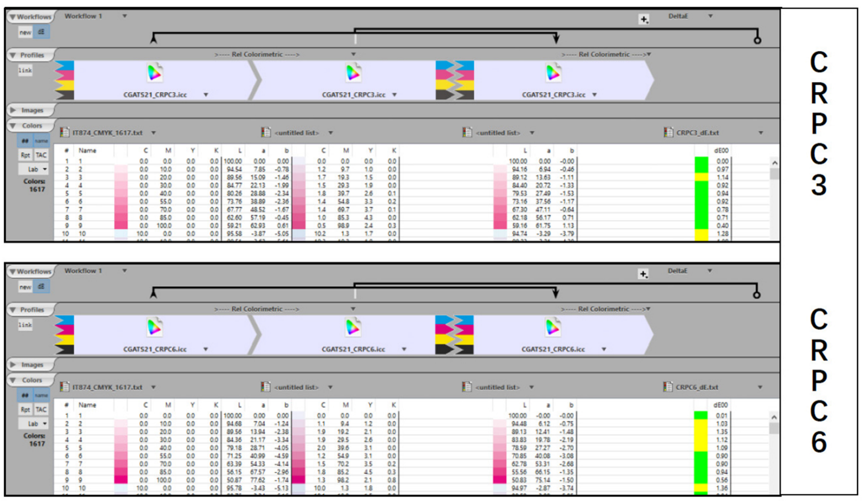


Figure 4 illustrates the vector plot of sampled image pixels between sRGB space to CRCP3 (left) as well as between sRGB space to CRCP6 (right). Both the 3-D view and the 2-D view indicate that the amount of visual loss in tonality and chroma is proportional to the magnitude of the vectors pointing inward with hue of the image pixels preserved. Thus, a dimmed reproduction (CRPC3) corresponds to the vector plot with larger vectors pointing inward (left). Particularly, there are noticeable chroma loss in the red (tomato) region of the color image.

“Round trip” is a technique of estimating the color conversion error (B-to-A-to-B) of an ICC profile. The round-trip begins from the legacy CMYK file, IT874_CMYK_1617.txt, which is the A or the device space. As shown in Figure 5, reported by Xinwei Wu who is a student in the class, the A-to-B conversion transforms CMYK values into reproducible CIELAB colors. This is followed by the B-to-A conversion (from a specified ICC profile) and, then, the A-to-B conversion of the same ICC profile using the relative colorimetric rendering intent.

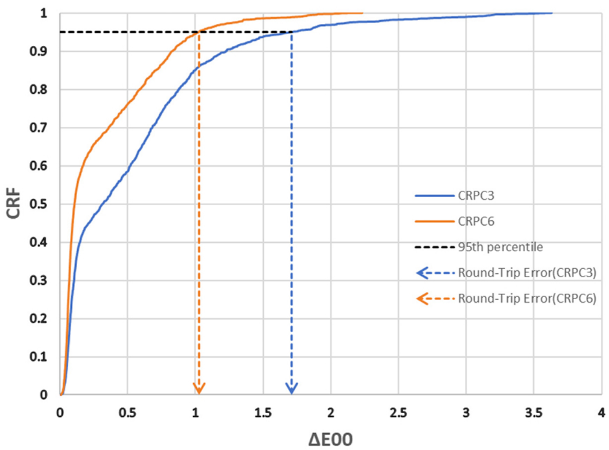
Figure 5

Using a worksheet for the round-trip analysis.



The B-to-A-to-B conversion of the color list produces 1,617 ΔE00 values. In a previous lab assignment, students learned how to use Excel to sort the ΔE00 list to generate a cumulative relative frequency (CRF) plot. As shown in Figure 6, also reported by Xinwei Wu in his lab report, the 95th percentile ΔE00 of the CRPC6 is around 1 ΔE00 and the 95th percentile ΔE00 of the CRPC3 is close to 2 ΔE00. This means that when assessing the reproducibility of Pantone colors by a CMYK output device, we should consider “no less than 2 ΔE00” as a color matching tolerance.

Figure 6
Round-trip errors of two ICC profiles, CRPC3 and CRPC6.



Conclusions

ColorThink Pro 3 is an ICC profile inspection utility. It can display the color gamut of a CMYK device in 3-D, 2-D, and spider plots. It can visually simulate color image reproduction workflows and quantitatively show how color reproduction quality is affected by the printing conditions. It can also be used to estimate the inherent color matching error of an ICC profile.

ColorThink Pro 3 was a new software to these students. If color management is the engine of an automobile, tThis lab assignment gave them a close look at what's underneath the "color management" hood. Many students found the lab assignment interesting, impressive, and important in their education and learning. By having hands-on ColorThink Pro 3, they gained insights into how device gamut influences sampled image pixels, and visual quality of the color image reproduction.

The author has used Microsoft Excel and Adobe Photoshop successfully in many lab assignments. Excel is good for number-crunching and graphing. Photoshop is good for visualization of color image reproduction and brand color reproduction. ColorThink is good for both number-crunching of digital data between device and PCS (Profile Connection Space), and visualizing color images in various color reproduction workflows. He recommends this lab assignment to interested faculty members in their academic endeavors highly.

Acknowledgments

The author wishes to thank Professor Xiaoxia Wan for inviting him to teach the online course in Wuhan University. He also wishes to thank Mr. Rick Hatmaker and CHROMiX for making ColorThink Pro 3.0.5 available during his teaching. Without the software support, the lab assignment would not have been realized. Last, but not the least, he wants to acknowledge the interactions he received from his students, particularly, Xinwei Wu, during his teaching.

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About the Author

Robert Chung is Professor Emeritus of RIT School of Media Sciences. He is the author of the book, Printing-Process Control and Standardization, published by RIT Press, in 2020. He has published over 100 technical papers in printing process control and color management. He was the convener of ISO/TC130/WG13, the working group responsible for developing printing conformity assessment standards from 2010 until his retirement in 2016. Bob was active in the development of CGATS standards concerning printing tolerance and the dataset conformity assessment for printing from digital data across multiple technologies. Bob was the recipient of the 2006 Michael H. Bruno TAGA Award for Outstanding Contribution to the Graphic Arts Industry, and the recipient of the 2007 GCEA (Graphic Communication Education Association) Kagy/Prust Life Achievement Award. He can be reached at rycppr@rit.edu.

Book Review: Printing-Process Control and Standardization by Robert Chung

Reviewer: Charles Spontelli, Associate Professor Emeritus, Bowling Green State University

Robert "Bob" Chung, the author of Printing-Process Control and Standardization, states the book was written as a text for college students who study topics in process-color printing technology and science. However, this is more than a textbook for printing students. Printing salespeople, project managers, prepress technicians, press operators, or any individual who buys or evaluates color printing will find interesting and relevant topics in this book. The first three chapters analyze tone and color measurement and color management. Many of the concepts and terms used throughout the color printing workflow are defined and well-illustrated in these chapters. Yes, there is theory here – and even equations, but there is also useful, practical information that printing professionals can use to expand their knowledge and enhance their work.

Contemporary process-color printing is inextricably tied to printing color standards, whether one is aware of it or not. The overwhelming share of color printing images and documents are generated from products in the Adobe Suite. The CMYK color working-spaces of all these applications are centered around standardized color specifications like GRACoL, SWOP, FOGRA, PSO, and ISO 12647-2. To create a CMYK image or document, the user should choose a CMYK standard working-space. If this is ignored, a default, commonly SWOP, is assigned. So-long-as common applications are used to prepare color documents, color standards will be applied. Bob Chung's book clearly explains these CMYK specifications, the color measurements that define them, as well as how and why they are used in the printing design and production workflow.

This book promotes the merits of standards. "it is the premise of this book that standardization helps maximize compatibility, interoperability, safety, and quality." The need for standards in the printing industry is driven by print buyers. Brands and other large print media buyers want and need consistency of color in their printed media. To a brand color is critical. It immediately identifies a company or product.

For example, Coke™ red is strictly controlled and monitored by the corporation and brand management companies hired by Coca Cola™. Standards and process control help printers to consistently meet the brand specification. Process-color standards provide color aim points that printers strive to achieve. Other standards offer guidance on how to calibrate CMYK printing devices to achieve standard color aims. Further standards deal with how well printing conforms to an aim or specification and how much variability is acceptable. "Conformity" is a popular topic in current print standards work. All these standards are covered in this work. Some of the standards are covered in detail – others are introduced with their fundamentals. If your work involves crafting color specifications for your company's print-media purchases, this book should be very helpful. Many of the color printing standards we consider commonplace have only come into widespread use in the last 10 years. From the late 1990s to about 2006, there was a period of color anarchy in the printing industry. Offset lithography was the dominant printing process of this era. Most printers then did not rely on standards. The same CMYK image file would noticeably change color appearance when printed by several printers. Print buyers didn't like this.

In the era when offset plates were exposed with halftone films, there was a de-facto industry 'standard'; it was linearized films (50% tone = 50% film halftone dot). These films were commonly proofed with 3M Matchprint™. This proof had tone and color characteristics that a competent printer could match well on press. By 2005 computer-to-plate (CTP) eliminated film and these de-facto 'standards' for most printers. Printers began to look for solutions. For a time, there was color anarchy in the printing industry. Each printer went their own way. In 2005, I participated in a presentation to the Printing Industries of Michigan. We proposed that the association adopt standards to achieve consistency for much of the local automotive work done at the time. We were politely told that "we print better than standards." Printing differently was viewed as a competitive advantage. Unfortunately, print buyers for the auto agencies didn't see it that way. Standards eventually were adopted. The compatibility and inter-operability that standards promoted turned out to be the real competitive advantage. This text promotes those kinds of printing standards. Creating a reference work for process-color printing standards was not a stated intention for this text – yet it is a very good reference. Formal ISO print standards began in 1995-1996. All the major process-color printing-related standards are indexed in the book's extensive bibliography. Every major ISO standard related to process-color printing is mentioned in this work.

If you are a teacher, you will like the short quizzes at the end of each chapter. The questions assess how well the reader understood the key concepts of the chapter. These can be self-graded; there is an answer key in the Appendix. It should give the student a heads-up as to whether they should return to the chapter for further review. Teachers will also be interested in the 'Test Targets' publication "teaching and learning journey" that Bob Chung describes. For 10 years, he led students to research color reproduction topics; they completed printing experiments and wrote about their results in a scholarly format. The work was formally reviewed. Then, the students were tasked with the design and prepress preparation of the final 'Test Targets' printed publication. Also, Bob recruited Franz Sigg, an RIT print researcher, to mentor students and contribute his research findings to the publication. He also enlisted the help of at least 10 graphic arts companies to collaborate with students and provide all matters of material assistance. Talk about student engagement – the problem-solving experiences, teamwork, and industry contacts will guide their careers for years to come. The description of the 'Test Targets' "journey" offers a multitude of ideas and ways for teachers to engage students to take theory into practice. The book should be helpful to teachers of color reproduction and related topics.

Bob Chung is uniquely qualified to bring together the myriad of details that comprise printing process control and standardization. He taught most of the concepts in this book for over 36 years in the School of Media Sciences at Rochester Institute of Technology. RIT continues as a preeminent school for the study of color imaging and printing. Students from around the world choose RIT for an opportunity to work with notable professors like Bob Chung. Bob is active in graphic arts standards groups like CGATS – Committee on Graphic Arts Technical Standards, TAGA – Technical Association of the Graphic Arts, and the ISO/TC 130 – the ISO committee for international standards within print and publishing. Bob has presented numerous professional papers on concepts explored in this book. I personally attended several of his TAGA presentations. He is always the ‘teacher’ as he shares his research and insights with the industry’s technology leaders. Bob has won awards from both the technical and education associations in which he participates. The author has spent much of his career helping craft standards for the printing industry. Standards work is all volunteer. It is considered a great contribution to the industry.

Conclusion

Printing process controls and standards govern every aspect of contemporary process-color printing. Whether it’s an analog process like offset or flexo or a digital process like web production inkjet, the concepts of this book apply. Anyone who buys, sells, produces, or teaches process-color printing can benefit from the ideas presented with the excellent illustration, and yes, there are equations. There is also considerable depth to the content. There are so many small details, especially in standards, this book cannot include them all. However, all the standards are indexed, and the complete works are readily available from the ISO and other public sources. Process control and standards continue to improve the quality and compatibility of process-color printing to the benefit of all stakeholders.

Book Publication Information

Chung, R. Y. (2020). Printing-process control and standardization. RIT Press. (ISBN-13: 978-1939125743; ISBN-10: 193912574X)

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Print technology, teaching, and printing research have been Chuck’s life-long passions. He taught printing technology and color classes at Bowling Green State University for 36 years – now an Associate Professor Emeritus. Chuck has worked in process-color printing standards since 2005. His current work involves a novel approach to CMYK device calibration – the Optimal Method. Chuck presented this work at the 2018 TAGA Annual Technical Conference. He uses the Optimal Method to help printers and buyers calibrate CMYK analog and digital presses and proofers to match any contemporary CMYK standard or custom reference. He also made technical presentations at TAGA and CGATS on topics of color measurement in the pressroom (led to ISO 20654 – Spot Color Tone Value), Color Management with OBA’s, Improving Print Standards (the basis for G7 calibration), and Modeling Colorimetric Tone Reproduction. https://optimalmethod.org/

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