The Color Engineer

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Introduction

There are several colleges that offer excellent training and degrees in Color Science. I know of none that offer the same in Color Engineering. In this brief, non-technical paper, we explain some differences in scientific and engineering with respect to color, and argue that we should have colleagues who identify themselves as Color Engineers and we should have colleges that offer degrees in Color Engineering.

Scientist versus Engineer

This discussion is risky as it easily invites useless controversy over fine points of terminology or job descriptions that are relatively unimportant. However, the issue is very important if we are not producing sufficient volume of trained and credentialed people with the skills needed. I think this is the case. As to the terminology, one might characterize the difference being that on the one hand we are seeking truth and knowledge, the scientist, and on the other hand we are trying to design products, the engineer. Both are very worthy endeavors and the best people in each kind of activity are equally talented. But they are different kinds of activities and in the extreme cases require different training, aptitude, interests and skills.

The difference in the disciplines, perhaps most important to a discussion about color, is that the product developer needs to clearly understand which scientific knowledge is crucial to the development of a given product and which knowledge, although deep and exciting in its own right, is essentially irrelevant to the product. Further, there is the case where a scientific reality must be faced in a product design and is expensive or for some other reason is prohibitive to handle. In this case, the product developer needs to know approximations or work-arounds that allow acceptable products to be designed and built. The knowledge of what is relevant, what is not and the skill to cleverly work around or approximate solutions is the essence of engineering.

There are also "reduction to practice" skills that are an important part of Color Engineering that are now up to each individual to acquire with little help. An example is the difference of "precision" and "range" as they apply to representing color values numerically within a computer. These are common concepts known to computer engineers and numerical analysts but often misunderstood or ignored when some of our best color science is moved into a computer implementation. Using known terminology is also important for better communications. The Color Engineer also needs to learn a lot of computer science and engineering.

Shifting Sands

In the historic spectrum we may be at a turning point. Humans have been limited in how they can produce colored objects or materials, as it was an issue of re-introducing colorants or mixtures of colorants already provided in nature. Scientific investigation is the primary tool to understand what nature provides and how we react to it. Synthetic chemistry has changed that in the last half century, but far beyond that, the digital computer has brought a new level of manipulative power and speed to the production of colored materials never before possible. For example, an Adobe® Photoshop® user can, in an instant, produce effects that were impossible to do with film, lights, filters, and a dark room.

The variety and volume of color-producing products has increased dramatically. This will continue. This calls for more skilled Color Engineers that understand color and its impact on product design. These engineers must also have a good grasp of computer engineering since it is such an important part of new color products.

Examples

Invariably at a conference some color scientists will give a demonstration of one of the very unusual anomalies of the human visual system. The adaptive nature of the human visual system contrasts with the nice constant results possible with physical instruments under controlled conditions. A typical demonstration shows how the exact same material, when placed into two different contexts, appears dramatically different to us. Demonstrations that emphasize differences in apparent color are quite dramatic. Gaining this knowledge of how the human visual system behaves is very important science. It is also genuinely interesting.

But the Color Engineer must ask "So what?" This is not meant to be a flippant remark but a sincere inquiry. Some scientific facts are very important to a given product development, others are not, and for still others it may be immaterial because even if it is important, nothing can be

done about it. Personally, as an aspiring Color Engineer, many of these scientific demonstrations seem irrelevant to what I do. If objects or colors appear different in different contexts I may not be able to control the contexts so about the best I can do is to review a small set of the most common contexts and make sure that the results are OK in each. In other cases, the contextual differences may be quite common across humans, predictable and reproducible. In those cases I can change the object to the fixed case that I want and get no surprises; I can control what I want

Imagine the developer of a desktop color printer who has just finished listening to a lecture on the effect that the illuminant has on the perceived color of a reflective object. Fluorescent lights causes the colors on a printed page to look quite different from those produced by an incandescent bulb. She is pondering of what importance this might be to her product development. The thought comes that this problem has existed long before her efforts to make this particular printer. She wonders that when she arrives at her home this night to find her spouse sitting on the sofa reading a magazine, is he likely to turn to her and say "I cannot for the life of me understand why Time Magazine produces these color advertisements to be viewed under fluorescent fighting when they know that the common reading environment in homes is incandescent!" This has never happened to her; this is not likely to happen to her. So we return to the basic engineering question "So what?"

The "what" in this situation is probably that the originator of the colored material *does* have a preferred viewing environment and produces the original materials with that in mind. The desktop printer needs to be designed to reproduce the output as faithfully to the originators intents as possible. On the other hand, the reader of an advertisement is familiar with this problem. There is considerable adaptation by the human, built-in, subconscious and conscious that lessens the seriousness. There is little to be done about it anyway. Fact: the material in a magazine will look different under different lighting conditions.

The engineer need not only listen carefully to the scientist but needs to do the further "So what?" analysis. What have the scientists learned that is important in which situations? As an explicit discipline, those lessons learned are passed on and documented in the discipline's database. To burden the scientist with this kind of activity would slow the scientific effort. The scientist must march forward discovering more truths. There is also a feedback from the engineer to the scientist asking for basic principles where there are none and explaining the observed anomalies so that they might be understood and eliminated.

Call to Action

What can be done? These disciplines are not distinct. Those engineering oriented color scientists can form special engineering subgroups or, in a college, sub-departments and eventually independent departments. They could teach some of the engineering knowledge and skills in explicit Color Engineering classes. They can work closer with their computer-engineering colleagues to absorb those cross discipline skills so needed by today's designers. On the other hand some of the more scientifically oriented engineers can learn more color science. They can meet the former group halfway. Just acknowledging the notion that there is an activity that can be called Color Engineering goes a long way to making it real.

Lastly, giving this presentation to this audience is preaching to the converted. Many of you are practicing engineers who are designing and producing exciting color products. You are already "The Color Engineer."

Biography

Jim King is a computer scientist that has for the last twelve years spent part of his time trying to become a Color Engineer. He has been at Adobe Systems since 1988 when he joined them to start the Advanced Technology Group. Before that he worked for IBM Research both in New York and San Jose. Dr. King has attended and been part of the organizing committee for all of the Color Imaging Conferences. He is now the Executive Vice President of the IS&T.

Special Note

This paper is identical to the one presented by James King at the first Color Imaging Conference in 1993. At that time Dr. King created a button that the attendees could wear that said, "I am a Color Engineer." Those buttons have developed into an annual tradition. The discipline of Color Engineering is certainly recognized now more than in 1993. The Color Imaging Conferences cover much engineering material and have helped to promote and develop the discipline of Color Engineering. But there is still more to do so that the Color Engineer can have a solid body of standard material and training to draw upon.