Making and Using Color Profiles in the Classroom
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Abstract

For approximately $750 an educational institution can buy a spectrophotometer and its associated control software. Hooked up in a classroom, the software will send color patterns through a projector, and the spectrophotometer will record the colors it detects on the projection screen. Together, the projected (stimulus) colors along with the perceived (response) colors will be used to create a color profile (a small text file) for that projector. The profile can then be used on laptops driving that projector to correct the VGA voltages driving the projector so as to maximize color fidelity.

Using color profiles in the classrooms has proved to be especially advantageous with Macintosh laptops, as Macs use a 'hotter' gamma value than Windows laptops, with the frequent result of displaying washed-out images. However, a color profile is much more than a gamma corrector; it maximizes the color gamut of the device (projector) from the shadow detail through the highlights.

Color Calibration versus Color Profiling

We have been calling the above process color calibration. However, color management experts carefully use, and distinguish between, the terms calibration and profiling. The former means to maximize the behavior of an instrument and/or to get consistency. The latter means to create an International Color Consortium (ICC) file describing the color behavior of a device.

For projectors, calibration means hooking up a known quality signal generator, feeding that signal to the projector, and adjusting the output according to agreed-upon criteria. For example, A-V installers frequently project a PLUGE pattern, using the brightness controls to adjust black levels, and a grayscale ramp pattern, using the contrast controls to adjust white levels.

Profiling means to characterize a device as to how it inputs or 'sees' color (cameras, scanners) or outputs color (printers, projectors, monitors). A profile is a text file with sets of numbers describing the color response of a specific device.

A color profile is a set of numbers, saved in a specific format, as defined by the ICC. The numerical values in that file can be used to correct or offset the input or output of a device so that its possible set of input or output colors, or gamut, is closer to absolute color values perceived by most people as determined by studies of human perception done by the Commission Internationale de l'Eclairage (CIE).

Generically speaking, a video card has hardware called a RAMDAC. Numbers representing images to be displayed are placed by the computer operating system into the RAM part of the RAMDAC. The Digital-To-Analog Converter (DAC) changes these

numbers into voltages that drive a monitor or projector through a VGA cable. The red, green, and blue voltage magnitudes drive the projection device to construct the displayed or projected image. The DAC uses another part of RAM as a Look-Up-Table (LUT) to make the translation between numbers and voltage levels. The beauty of a color profile is it can alter or adjust the values in the LUT because it "knows" what values are needed to maximize the color fidelity of a specific device. Note that if the wrong color profile is selected, then the displayed output may be much worse.

A color profile is generated from a stimulus-response set-up. For projectors, we demonstrated the use of the Beamer from GretagMacbeth, a spectrophotometer. With a computer driving the Beamer through a USB connection, the software (Eye-One Match) sends color values (stimulus numbers) through the VGA cable to the projector. The Beamer then reads those color values from the projected image and generates a table of response numbers. These two sets of numbers allow the construction of a color profile; a text file that can be used to adjust the LUT in the video hardware to maximize the color fidelity of the projected image.

Practically speaking, with approximately 125 projectors deployed on campus, we do not have adequate staff and funding to calibrate this pool of projectors. Instead, we leave the projectors with default settings, typically zero, i.e. brightness, contrast, etc. We then create color profiles for specific projectors in classrooms where instructors request our assistance with projected image quality.

Beamer Set-up

In a classroom, we place the Beamer at the approximate physical location of the projector, pointing towards the projection screen. For example, with a ceiling-mounted projector we position the Beamer more or less under the projector. A laptop with the Eye-One software is placed close to the Beamer and connected with a standard USB A-B cable.

The UCD classrooms have a media cabinet positioned at the front side of the classrooms. From a drawer in these cabinets, there is a useable length of about twenty feet of VGA cable with which to hookup a laptop. Twenty feet of VGA cable will not allow proper positioning of the Beamer in our larger classrooms. Hence, we carry a 75-foot VGA extension cable for this purpose. Additionally, we carry a long power cable with which to power the laptop if necessary. In the large classrooms, the Beamer setup is basically out in the audience.

Some of our computer labs present a different problem, where the master computer driving the projector is locked down on a table close to the projection screen. In these cases, we run an active USB cable from that computer out to the Beamer.

Room Lighting

Lighting is critical. If there is too much ambient light on the projection screen, the Beamer cannot make a useful profile. The Eye-One Match software will state, at the end of making a profile, that the profile may be damaged and not useable.

Many of the smaller UCD classrooms do not have good control of the overhead lighting. Instead of having distinct front and back banks of lights, these rooms have lighting banks that run from front to back. Consequently, with either bank of lights on, there is overhead light pouring onto the projection screen. The only way to achieve good lighting conditions for optimal color is to turn off all room lighting, and then open up window blinds in the back of the room to let in some light so students can still take notes. What is done depends on the wishes of the particular instructor. Consequently, due to excess light, there are situations where nothing will make the color look good.

Making and Using Profiles

The first screen of the Eye-One software allows selection of the type of device being profiled - in our case, a projector. The Beamer then requires calibration. The holder has a built in shutter for this purpose. The next step is to properly aim the spectrophotometer at the screen, which is done by outputting a series of colors through the projector, at the end of which a target circle is displayed, hopefully, on screen. The Beamer holder is then moved to approximately center this small target on screen. Continuing forward, the Beamer checks its alignment by displaying a series of black circles, decreasing in size, almost like creating a bull's-eye.

With a successful alignment, the profile creation part can now be started. This stimulus-response procedure takes about two minutes. Known colors are output and the projected colors detected. By the end, a profile is created. Using Mac OS X, a default location in the user account and a default file name is suggested. Selecting OK saves the newly created profile and makes it active.

We demonstrated making two profiles, one using the easy method and one using the advanced, with a Macintosh laptop. The advanced setting allows control over the color temperature, from 5K to 7.5K in .5K steps. In one case at UC Davis, we made profiles at all possible color temperatures so the instructor could choose which profile made his projected images look the best. This can be instructive, as you can then see the color temperature differences, going from the lower reddish to the higher bluish temperatures. Normally, we would make profiles at 6500 degrees, as that is the standard used by most photographers in our media group and by projector manufacturers.

We then showed an image using the two newly created profiles, as well as available generic profiles. This process is especially easy on the Mac since it is dynamic and the results of any profile being selected can immediately be seen. On all Windows machines we have tried this, but a reboot is necessary, making instant comparison impossible. Additionally, the Mac video architecture allows for individual selection of a profile for the laptop screen and for the external device, i.e. monitor or projector. This allows for the best color fidelity simultaneously on both devices. To date, we have seen no Windows laptops that allow this; the profile selected controls both the laptop screen and the external device. We keep a set of profiles on a USB flash drive and on CD-R, so, if a profile for a particular projector has already been made, we can go to a classroom and quickly load one when necessary.

Experiences

The majority of instructors using these projector profiles are satisfied with the results because the projected images are no longer washed out and the subtle detail shows up. Using these color profiles has greatly helped showing images of geologic sedimentation layers, stained cells, volcanic activity, botanical samples, paintings, psychological perception of color, agricultural crops, PowerPoint text with color changes for emphasis, and even Excel spreadsheets with subtle shading between cells.

There have been a couple of exceptional cases, both positive and negative.

One instructor had extremely high quality images of paintings in the Louvre. As an Art Historian, he had an extremely critical eye as to color in these displayed images. Before profiling the projector, he was extremely unhappy. After color correcting the projector, his response turned from frustration and dismay to pointing out very picky color problems, slide by slide, with comments like: “this red is not quite right”. He declined further experimentation with specific color temperature profiles, as he was extremely satisfied with the overall result.

On the negative side, one instructor did not benefit from using a color profile. The reason was simple: room lighting. He would not turn the room lights down or off, with the result that the projection screen was awash with ambient light. In the game of color, color is light. There must be a dark screen. Even the best image will look crummy on a projection screen if there is too much room light on that screen.

Another specific problem we could not overcome was profiling a Dell 2300MP DLP projector. This particular projector would not display yellows well, even in a situation where we could completely control room lighting. However, the same images when displayed on other projectors looked correct. We do not know if this particular projector was defective or this failure indicated a more general problem.

In another case, an instructor had thousands of images. She showed 80 – 100 images per lecture. The quality of these images varied so much that a color profile would make most of these images look better but would actually degrade the remaining images. This seemed like a textbook example where complete color management of the original images would ultimately pay off, i.e. profiling her office monitor, scanner, and printer, and then correcting all the images in Photoshop under known conditions. This process would allow the display of all of the images to maximum advantage. However, learning to color manage a workflow is not trivial.

Practical Considerations

• Lighting. Some instructors are loath to get a classroom dark enough, instead wanting to keep plenty of light in the room for both note taking and keeping students awake (perhaps even to keep the instructor awake). With too much room light washing over the screen, all color bets are off.

• Lighting. Towards the end of projector lamp life, it appears the spectral profile of the lamp has degraded to where the colors seem flat, even with color correction. Nevertheless, from a cost standpoint, lamp life needs to be maximized. At worst, the lamp light output may fall to near 50% of the original output, as that is a common definition of projector lamp life.

• Lighting. Apparently all projector lamps have a two-step decrease in red output, one at about thirty hours and another at about one hundred hours. We are told that this step function can be seen if the spectral characteristics of a given lamp are obtained. Presumably, under worst-case conditions, several profiles might be needed for a projector if the color requirements are very stringent. To date, this level of support has not been requested.

• Profile Location. On OS X, color profiles for displays can be located at any or all of three locations. By using the ColorSync Utility included in the Utilities folder, these locations can be conveniently seen. With the ColorSync Utility open and Profiles selected, this application will show all installed profiles. The three locations are called System, Computer, and User. A fourth location called Other may refer to printer profiles or other profiles installed by Adobe applications.

The Eye-One software always puts the newly created profile at the User level, i.e. ~/Library/ColorSync/Profiles. This is not the best location since any profile in a specific user account is for that account only. Additionally, there may not be a ColorSync folder available at this location unless an Adobe application has been installed. The best location is at the Computer level, where the profile will be available to all accounts: /Library/ColorSync/Profiles/Displays/.

In Windows XP, the color profile path is: C:/Windows/System32/Spool/Drivers/Color. If you have a profile on the desktop, it is extremely easy to place that file into the correct (buried) location: right-click on the profile and select “Install Profile”.

The System location should be left alone, both on the general principle of not altering the operating system environment and because authentication is required, which one may not have. This path is: /System/Library/ColorSync/Profiles/.

• Adding software to a computer. Color profiles for projectors are very small text files, typically in the 12 K byte range. Nevertheless, if any file is added to a computer, that user may come back months later complaining that their machine no longer works, and the reason is because “You loaded Software on it”. To date, we have not had this problem loading profiles.

Nevertheless, this is obviously a case for making a judgment about the user. Personally, if I get a bad feeling about a user (I know, so vague, and yet I bet you know what I mean), I start talking first about exactly what the possible consequences might be -

things like adding any files to any computer might cause problems, not because of the file but because of pre-existing problems; has the user backed up the system; what would the user do if your computer crashed, etc. Just deal with these cases head-on, and do not add files if the circumstances seem wrong.

When adding or modifying video drivers to a computer, the operating system is being modified. This is not necessary when adding color profiles, but do not add them at the System level on Mac OS X. Unfortunately, many laptop users do not update video drives or other associated software such as the BIOS and sometimes the video BIOS. Those updates frequently squash bugs and/or add better functionality, allowing more consistent control over mirroring, extended desktop, setting the primary monitor, etc. We never modify faculty machines unless they give us explicit permission to do so and we have discussed backup, etc.

• Video architecture. With a Mac, one can independently and simultaneously use different color profiles for the laptop screen and for the projector, maximizing the color fidelity of both devices. This is even true on the cheaper iBooks that do not support an extended desktop, although it seems counter-intuitive to be able to do so on a mirrored system.

With all Windows laptops we have seen to date, any selected color profile is used for both the external projector and the laptop screen, with the result being the projected image will look great but the laptop image poor, typically pink.

• Video architecture. With a Mac, color display profile selection is dynamic, i.e. any selected profile immediately becomes the active one. Therefore, one can easily see the results when choosing different profiles. With all Windows laptops to date, a newly chosen profile will become active only upon reboot. This feature on the Mac makes it extremely easy for an instructor to compare the results of different profiles.

• Profile activation. In System Preferences/Displays Preferences there is a window associated with each active display system where things like resolution, color depth, and scan rates can be chosen. Additionally, each window will have a Color tab, where a color profile can be selected.

With no external device attached (monitor or projector), a profile for the device to be attached at a later time, cannot be selected. This behavior, although logical, inconveniences some instructors because they want to be prepared before they get to the classroom, and they sometimes choose the wrong profile for the laptop screen. Occasionally such a user will start a trouble ticket, not seeing what they did; thinking a profile for a non-existent external device has been chosen.

Indeed, two things compound this problem: display selection window placement and window titles. With an external monitor or projector attached, the OS X Displays Preferences will open two selection windows (or even more with more attached devices, like when using a VTBook card for projection on two projectors). Each window will

have a title. The window for the laptop screen will typically, although not always, be entitled “Color LCD”. The window title for the external device will vary a lot. With monitors, the title will frequently include the name of the exact monitor, for instance Apple Studio Display or Dell 1800FP. With some newer projectors, the window title will include that projector’s name like Sharp or Hitachi. With other newer projectors and most older projectors, the window title will be generic, something like VGA Display.

The more specific, and useful, titles are coming from projectors which either implement the Display Data Channel (DCC) protocol better or use newer DDC protocol versions. (DDC is a complex topic in itself - how it works, what information really does come from the projector to the laptop, how that information is utilized by the laptop video driver, etc.).

Having window titles that may be too generic confuses the user in device selection, and older versions of OS X (pre 10.4.x) sometimes displayed both selection windows, one on top of the other. That is, one of them was hidden, leaving the user unaware that there were two selection windows. Or perhaps the projection mode was still in extended desktop rather than clone or mirrored, leading to the well-known A-V support problem where the user is looking at the laptop screen and not what is coming from the projector. OS X 10.4 has added a “Gather Windows” function to help with the extended desktop problem, bringing all Display Control Windows to the primary display. (Dealing with primary/secondary monitor selection is another can of worms except with laptops having the Intel Graphics chip.)

• Use of ColorSync. Every installation of OS X includes a program called ColorSync Utility. Two useful features of this program are Profile First Aid and Profiles. Profile First Aid will find and verify or repair all profiles on your computer. This aspect of the ColorSync Utility can fix common problems found in the profile structure. You may be surprised by how many profiles there really are. An average OS X Tiger installation will probably have close to a thousand, most of them being printer profiles supplied by printer manufacturers.

The paths to printer profiles are complex. Many (most?) are in the path: /Library/Printers. Then, selecting a specific printer vendor, like HP, there may be a Profiles folder associated with that vendor. But the actual profiles for specific printer models are likely to be buried in package contents in plug-ins. For example, choosing HP/Deskjet/ and then Control-clicking on an HP DeskJet plug-called hpdjPM.plugin, select Show Package Contents. The remaining path, in this case, is Contents/Resources/ICCProfiles/deskjet. Here there are 27 DeskJet color profiles.

Selecting the Profiles feature in the ColorSync Utility is useful for a couple of reasons. One feature is it is a handy reminder of the profile location hierarchy discussed earlier, between a single user account, all users, or the operating system. Another feature may aid troubleshooting. In ColorSync Utility you can examine a three dimensional Lab plot of a profile. This plot shows the gamut of the device, i.e. what colors it can capture or display. One gamut can also be compared with another. For example if you select a

typical Apple Studio Display profile, hold it for comparison, and then select a projector profile, this comparison often shows that some colors can be seen on the display but cannot be projected. Likewise, the projector may be able to project a range of hues which the display cannot show. Such a comparison might be instructive in analyzing a particular situation.

Additionally, it can be instructive to compare a good projector profile with a bad one, i.e. one where there was too much light on the screen with the result that the Eye-One Software 'complained' about the Beamer-generated profile. Where a normal profile is a relatively smooth three-dimensional object, a bad profile will tend to look quite different, perhaps with great exaggeration of some hues and an almost complete absence of others, rendering an ugly distorted object.

For example, the profiles we made for a Dell DLP projector under completely controlled lighting conditions on a projector which could not display yellow well, actually show that characteristic in the Lab plot. In that plot, there is very little yellow hue available, whereas the red seems greatly exaggerated.

The color management folks who make and implement many profiles in their production process, and who benefit from such profile comparison, will frequently buy better software for this purpose, such as ColorThink from Chromix, of which there are both Windows and Mac versions. This software allows comparison of many profiles simultaneously.

• Making profiles. As is so common in supporting A-V needs, we sometimes get an urgent problem phone call at the start of class. If we have a profile for that room (we have not yet made profiles for all 116 rooms), then we can dash over to that room and install and select an appropriate profile, taking up almost no class time. If we do not have a profile for that room, but have a profile for the type of projector in that room, for example a Sharp P25, we have to make a judgment about whether such a profile will work. My experience is that some P25 profiles work well enough in other rooms with P25s, but the room conditions need to be approximately the same. In general, a profile made in one room will work well enough with any number of laptops in that room but will not transfer well to another room.

A much safer route is to make a profile as soon as possible and email it to the instructor with installation instructions. A follow up visit to the next class is strongly advised. We do have 20 minutes between classes at noon, enough time to make a profile, but, in general, doing so does not work. The lighting conditions in the room must be kept constant, and we must keep students from walking in front of the Beamer during profile generation. With our classrooms frequently booked, we seek out and utilize the rare opportunities during the day when the classrooms are empty or make profiles at night or on the weekends.

• Profile file names. Color profiles are tricky in that they have both an external file name, easily changed, and an internal file name, not so easily changed. In the OS X

Displays Preferences Color profile selection window, the internal names are displayed, but not the external filename. For instance, if an instructor changes the external file name to something more useful, that new name will not be seen when trying to find and select it. To date, much of the software available to synchronize the external and internal file names seems work only occasionally or is tricky to use. Therefore, having a strategy for naming the profile once created by the Beamer is important. We tend to name the file by classroom, such as Hutch115. That way the instructor can easily find and select it. We also have additional file name information such as the date created and sometimes the color temperature and gamma, but the room name is always at the beginning of the file name.

• Projector suggested profiles. Many projectors will "suggest" a color profile. In the OS X Displays Preferences Color profile selection window, there is a check box called "Show profiles for this display only." Either there will be a suggested generic profile or a specific one, which may or may not have a specific projector name. Some profiles will have specific names like Epson, plus a model number. Others, like a Hitachi 1200 will suggest LCD Projector. The suggested profile has odd characteristics. It does show up as a file in the path for display profiles for all users, and it can be option-copied out to the desktop, so it is, at least temporarily, a real file. However, once the projector is disconnected, that profile no longer exists, as can be seen by searching for it from the Terminal command line.

Such behavior suggests that the operating system is constructing a profile from the information sent to it by an initial DDC interchange. In our experience, suggested profiles from newer projectors are much better than such profiles from older projectors, at least in the Sharp line. Nevertheless, a Beamer created profile will still look better in most cases than the suggested profile. In an emergency, a suggested profile may work well enough. For that matter, one can try selecting any available profiles to see if any of them will suffice for that class until a better one can be made.

Beamer Specifics

The spectrophotometer from GregtagMacBeth is one of the instruments that can be purchased with several of their color management packages. It is a versatile instrument that can measure both emitted and reflected light. The software allows the instrument to measure ambient light, for example you could verify the color temperature of a light box.

Buying the Beamer option includes an instrument holder to help aim at the projection screen and a code, and entering that code unlocks the projector calibration function. Unlocking this capability needs to be done only once since it is not tied to the software but instead unlocks the instrument itself. It can be tricky to carefully mount the spectrophotometer in the holder. One does not want to hear the horrible 'plink' sound, as I have, of a small plastic piece breaking off, after which the instrument can no longer be mounted in the holder.

Other Strategies

• Individual Classroom Projector Adjustment. This procedure, where we adjusted a projector at both the beginning and end of a specific class, is what led to consideration of the Beamer in the first place, since individual classroom projector adjustment is too time consuming and difficult to support. However, when equipment is rented from and set up by us, we can adjust the projectors for best quality presentation in a one-time venue.

• OS profile software. All versions of OS 9 and all versions of OS X have a built in "Color Calibrator", available in the Displays Preferences Color selection window. This software goes through a number of steps to create a profile based on your individual eyesight. A user is presented with a number of screens where sliders are adjusted until different screens look good. As OS X has matured, so has the quality of this software. Today, with Tiger (10.4.x), and care on the part of the user making adjustments, decent profiles can be created. It is still our belief that spectrophotometer created profiles are better. No such built-in capability exists yet in any of the versions of Windows.

• Application profile software. Windows users, running 2000 or XP, and having installed some Adobe package like PhotoShop, can create a profile by running Adobe Gamma. This software is not available for separate purchase. Like the Mac software, it leads the user through a number of screens with adjustments, to create a profile. In our experience Adobe Gamma is not nearly as sophisticated as the built-in Mac operating system software and does not give as satisfying results.

A shareware package available for Mac OS 9 and OS X is SuperCal from bergdesign. Like Adobe Gamma and the built-in Mac profile generators, this is "eyeball' profile creation, where a series of screens is adjusted. In all of these cases, squinting helps quite a bit. SuperCal is sophisticated, like the Mac OS software. It can produce a profile fairly quickly, or it can be used to make specific adjustments with red, green, and blue in brightness ranges, i.e. in the shadows, the midtones, and the highlights. Excellent results have been achieved.

• OS Color Tweakers. In a couple of cases, instructors have needed to show only a couple of images and have used various free software packages to make on-the-fly adjustments to the projected image. Many, if not most, modern Windows video drivers have the capability to adjust the hue, saturation, and gamma. Unfortunately, this capability is frequently difficult for instructors to find, most of whom do not spend time investigating this sort of capability of their laptops. Modern machines like a Dell Latitude 610 with the newer Intel graphics chips may help alleviate this problem since control menus are much more accessible.

• Application Color Tweakers. As stated above, this software may be useful when displaying a very small number of images. Having a Beamer-generated or an 'eyeball' generated profile is probably a better way to go in the long run, but this strategy has worked.

Several Geology instructors have used an OS X application called Gamma Control. This application presents a small control panel on the desktop from which one can adjust the RGB colors to get a better looking image.

Another OS X application sometimes used is Preview, included with all versions of OS X. With an image opened, under Tools, is a panel called Image Correction. In here, various things can be changed, including saturation, brightness, and contrast. Then, Slideshow can be selected for that, or a couple, of images.

Another OS X application is Image Tricks, which is like Preview but with much more extensive adjustment capabilities. In all of these cases, one a profile is not being created, but a specific image or images for a specific display device is being adjusted. This behavior is perpetuating reliance on device-dependent color rather then moving towards color management and device-independent color, something much more useful in the long run. Nevertheless, such immediate color correction will continue to be used, as doing so is much simpler for most instructors than spending the time to learn about and implement color management.

Future Considerations

Providing projector color profiles is not color management. It is one step in the process. Ideally, instructors, or their departmental support personnel, should know how to implement a color managed workflow. This would eliminate device-dependent color, where images are adjusted to look correct' on one particular display device, and lead to images adjusted under color management that look as good as possible on all display devices. That is, such images could be displayed and printed to maximum advantage.

To realize this ambition, we hope to collect a number of images used by instructors to see whether or not these images are tagged with profiles. This will hopefully give us some insight into the source of images. We will be looking for instructors open to the possibility of using color management.

Another goal is to locate and learn to use software that allows easy profile name synchronization between the external file name and the internal name. ColorThink has this capability to some extent, but some renaming actions do not work as one would expect. It might be useful to use the Beamer to measure the color temperature of a classroom, to see if such information could be used in a productive fashion.

We hope to generate color profiles from the Beamer for all of our rental projectors and then train our staff to use them. A Quick-Start type of guide about file location and selection would be useful.

It would be useful to investigate the role of DDC. Such an effort is two-fold. We need a way to capture the I2C data protocol between laptop and projector, and then we need to purchase various VESA documents to interpret this data. This would be interesting in and of itself to see if projector firmware changes the data sent by the projector, or if data is not being sent.

One immediate resource to try and correlate DDC data with VESA specs is through the Open Firmware still used by pre-Intel Macs. In the Open Firmware device tree, one can see the DDC data used by that particular display, i.e. it is already "captured' so to speak.

We hope to post a page describing some of the issues about projectors and color so instructors will have easy to find and use reference material.

Acknowledgements
The initial impetus for this work came from projection difficulties in the classroom but in two different forms. As staff who support classroom projection, we had a few cases where we needed to go out at the beginning of each class, adjust the projector, and then return at the end of class to adjust it back to the original settings, a time consuming, difficult-to-schedule process. Another source of concern came from a couple of the Information and Educational Technology (IET) photographers and artists. These people were spending a lot of time creating beautiful, color managed presentations which, when presented in some classrooms, were of poor quality in one way or another. At the very least, much subtle detail was lost.

In particular, I would like to acknowledge the extensive input from a color management expert and long time photographer on campus, Gabriel Unda. He made the initial suggestion of investigating the behavior of a Beamer, and participated in many of the early profile creations. He and an artist, Claudia Meyers, made important initial judgments about the usefulness of the Beamer profiles.

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