Colour communication challenges: Exploring disciplinary divides

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Sixteen students were involved in an experiment to describe the appearance of colour samples. These students were divided into two groups: design background and chemistry/engineering background. Design participants react to samples with images and adjectives describing their feelings and emotions. They tend to use evocative, emotional, and associative terms which are also related to use of a wide variety of semantic fields. On the other hand, chemistry/engineering participants focused heavily on colour and surface objectively. Although they used limited sematic fields compared to design participants, they used more precise language in their description. In terms of describing the process of changing the appearance of one sample to another, participants from chemistry/engineering used technical terms and described the process more systematically in comparison to the design participant group. The main focus of this research was to investigate differences in colour communication between participants from the disciplinary backgrounds. These comparisons are not intended to suggest negative or positive judgements by the researchers but to describe the different values of these participants. This research provides evidence that people from different disciplines who need to collaborate in colour design use different colour vocabularies.

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Introduction

Colour, Material, and Finish (CMF) design is a specialised area of design where the focus is on the three elements of appearance just mentioned. There are various professional areas in relation to the field of CMF design: colour design, colour development, material design, material development, surface design, finish design, CMF strategy, CMF development, trend tracking and forecasting, storytelling, and marketing. These areas overlap each other and there are no well-defined boundaries. For this reason, communication skill is an important asset for CMF professionals [1].

In the field of colour, there are two main groups of professionals found in the above list, who use colour and need to collaborate: designers (colour design) and chemists (colour development/ formulation). Colour design specialists analyse colour trends, preferences, and patterns in order to predict customers' future needs and the market demand [2]. Their role also involves consulting with clients, considering budgets, creating new colours and enhancing the emotional connection between colours and materials to provide high levels of satisfaction for customers. Many of these colour designers are employed by paint and coating companies.

Colour development requires people with a chemistry/engineering background. Colour chemists tend to work in laboratories, mixing pigments and thinners in measurable quantities to create new colours [1]. They also test paint strength and durability to achieve the best functionality.

Collaboration between these two groups of colourists is inevitable throughout the colour design process, from creating new colours to final product application. This is because both functional and aesthetic aspects need to be balanced for successful colour design. However, anecdotal evidence gained by one of the authors of this article while working in the colour design industry suggests that these groups of colourists often face communication difficulties. These problems may be because of a lack of shared and common understanding about different ways of describing colours, and because of different disciplinary backgrounds. This in turn can lead to negative attitudes towards each other and can adversely impact on the atmosphere of the workplace, especially among early career professionals.

The following is an example of the communication difficulties faced by professionals in the industry. During one design project, a design team was developing a leather effect surface that combined pleasantness to touch and colours for a mobile product. Various types of leathers, images, materials, and colour samples were provided during a focus group interview to extract leather-related words from colour expert groups (three chemist and three designer colourists) in order to create a colour evaluation scale. During the group session, one of the designers asked the participants "what do you feel when you look at those samples?" Designers actively responded to various materials and provided subject-related adjectives and nouns whereas chemists had a problem with this. This is common in the colour design industry from our experience. Designers frequently have to ask chemists to think carefully about their response to colour. Chemists reply that they do not understand the designer's meaning. A question which arises here, and which is the starting point for this study, is why do colour designers and chemists encounter communication conflicts despite looking at the same colours?

Methodology

Sixteen students took part in an experiment to describe the appearance of twelve samples. These students were divided into two groups comprised of eight from a design background and eight from a chemistry/engineering background. Tables 1 and 2 give details of each participant's education history. Table 3 summarises the composition of the two groups of participants by gender, age, and ethnicity. In terms of national/ethnic background, most of the design participants were Asians compared to chemistry/engineering participants who had a wider range of ethnic backgrounds including: British, Irish, Chinese, Malaysian and American. However, it may not be a serious weakness in the study.

Design is an international discipline regarded as one of the most creative and wide spread human pursuits [3-5]. In addition, although English was not the first language of all design participants, they all possessed a minimum level of English needed for study at the University of Leeds in United Kingdom on either masters or doctoral programmes. This all reduces the limitations of the study.

Participant	Undergraduate	Masters	PhD
D1	Design technology	Product design innovation management	Luxury brand design
D2	Graphic design	Graphic design	Information design
D3	Product design	Product design	Colour design
D4	Graphic design and advertising	Graphic design	-
D5	Visual communication design	Visual communication design	-
D6	Visual communication design	Visual communication design	-
D7	Fashion design	Women's wear fashion design	Fashion design and textile
D8	Oil painting	Graphic design	Information design

Table 1: Disciplinary background of design participants.

Participant	Undergraduate	Masters	PhD
C1	Analytical forensic chemistry	-	Pigment addictive interactions for modern and contemporary works of art
C2	Package design (BEng)	Chemistry	Colour science
C3	Biomedical material science	-	Textile processing
C4	Textile technology	Clothing management with textile	Textile (Functional fibre)
C5	Chemistry	Chemistry	Organic chemistry
C6	Chemistry	-	Chemistry
C7	Electronic engineering	Image and video communication and signal processing	Colour science
C8	Chemistry	Colorants, polymers, and fine chemicals	Perceptual and instrumental measurement of translucent materials

Table 2: Disciplinary background of chemistry/engineering.

Demographic details		Design participants	Chemistry/Engineering participants
Gender	Male	25%	25%
	Female	75%	75%
Age	29 years or younger	75%	62.5%
	30 years or older	25%	37.5%
Ethnicity	British/European	0%	25%
	Asian	87.5%	62.5%
	Other	12.5%	12.5%

Table 3: Demographic characteristics of participants.

Nevertheless, it should be taken into account that English is the second language for most of the participants and this is evident in some lack of fluency in the quotations given below.

Six alphabetically coded pairs of colour samples were used for the experiment. Each sample within a pair, differed from the other as follows. Pairs A, B and C differed in colour; pairs D, E and F differed in gloss, texture, and colour (Figure 1). For every pair, each sample was shown individually and then both samples in the pair were shown together. Participants were asked to answer the question "how would you describe sample X" for each sample. Then they were asked to describe the process of adjusting the first sample from each pair (for example, A-1) to make it look like the second in the pair (A-2). The word 'colour' was not mentioned by the experimenter during this process as it might influence participants to describe and talk about colour only.

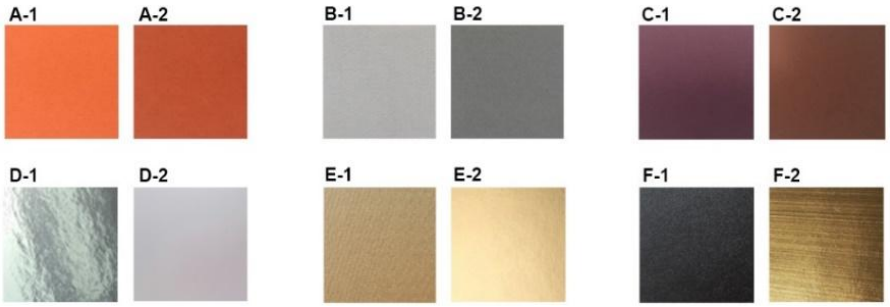

Figure 1: Pairs of samples used for the experiment.

Results and Discussion

Evocative, emotional and associative terms

It was observed that design participants tend to respond to samples emotionally in terms of evocation and association. They used evocative, emotional, and associative terms such as "reminds me", "it makes me think", "feel", "it look(s) like", and "it's saying to me" more often in comparison with participants from chemistry/engineering. Design participants were approximately twice more likely to use these terms associated with feeling/memory than the other group (Table 4).

Disciplinary background	Design	Chemistry/Engineering
Emotional/Evocative/ Associative terms	Frequency	
Feel	88	77
Reminds me	5	8
Makes me think about	46	0
Look(s) like	35	14
It's saying to me	11	0
Total	185	99

Table 4: Frequency of emotional/evocative/associative terms.

Although participants from chemistry/engineering background used emotional, evocative and associative terms, they were still likely to describe what they were looking at objectively. There are several examples. Participant D1 and C4 show distinctive descriptions describing sample D-1 as follows:

> "To me it's saying hey I'm bling-bling, I attract attention, I am shiny, I am expensive, don't touch me just look at me, but I am going to touch it, and again when I look closely at it, it has got a glossy, surface, also has a texture" (Participant D1, describing sample D-1)

> "It looks like an aluminium foil, it has shiny, but it has just smooth surface. I can see it has some mirror image." (Participant C4, describing sample D-1).

Similar approaches were clearly shown by participants D8 and C3 describing sample E-1 as follows:

> "Dirty, warm, well, uncomfortable, and this colour make me think about poor places, not well organised places, like in the very dirty, dirty underground or dirty village. Yeah that kind of feeling. And it makes me think about the autumn, especially leaves down, so it makes me feel uncomfortable. And dirty basically." (Participant D8, describing sample E-1)

> "It looks like paper pulp with a beige pigment to it. This one looks quite rigid. And yeah, don't know what more to say about it." (Participant C3, describing sample E-1).

Associations of sample colour with images and memories

Design participants expressed their responses using adjectives about feelings, images and memories. These are also closely connected with evocative and emotional language uses that are mentioned above. Lawson (2004, p.93 as cited in Bartlett, 1932) notes that "evocativeness of words is a function of our long-term memory which is conceptual and schemata based" [6]. The author also states that designers acquire higher levels of sophistication and elaboration in schemata for concepts they deal with [7].

D1	natural, earthy, blend with environment, calmness, smooth, made of card, wood paper pulp
D2	chocolate, coffee, forest, feel Africa, cosmetic, foundation, hair
D3	wood, fence, good for clothes
D4	out of fashion, elder people like, earth
D5	wall, building in the Lisbon, Lisbon city
D6	same as C1 just colour different
D7	buildings, house wall,
D8	boring, autumn, sadness, old style, old building, rough, very cheap

Table 5: Language use in response to sample C2 by design participants.

C1	burnt umber
C2	brown, soil, leather, bricks
C3	similar to C1, robust, rigid, matte black finish
C4	brownish, smooth
C5	matte, brownish red, earthy, pottery, smooth looking, browny beige
C6	brown, tan, between brown and orange, more brown side, not reflect, quite opaque
C7	wood, natural, soft, brown, matte
C8	cognac, rust, orange, slight orange, mostly brown, shoes

Table 6: Language use in response to sample C2 by chemistry/engineering participants.

Design participants associated samples with a range of images. There has been a crucial place for imagination in considerations of creative behaviour and the formation of ideas [8]. For designers, what they were feeling at the time may have been important. For this reason, during the whole process some of them did not mention the names of colours at all. Interestingly, for sample C-2, none of the design participants mentioned the name of the colour while all chemistry/engineering participants did (Tables 5 and 6).

Similar contrasts between the two groups are clearly shown from sample D-2 (Tables 7 and 8). One design participant mentioned colour whereas all chemistry/engineering participants describe the sample with a colour focus in terms of its surface. Distinctive differences can be seen comparing participants D5 and C1 describing sample D-2.

> "Ah, I think it is more like a foggy than sample D-1. And um, peaceful, I don't know it makes me feel like I am going to die, if I see this colour everywhere I feel die, yes I mean I am just dying naturally." (Participant D5, describing sample D-2)

> "So this is a lighter silver, so it's not pewter, it's lighter so a light silver. It's matte in finish. It's very opaque so it's changed in opaqueness the other one [D-1] was almost transparent, like mirror like. This one isn't this is completely matte, complete opaque and a light silver. The paper probably looks the same thickness as sample D-1." (Participant C1, describing sample D-2)

D1	wet, matte, smooth, calm, not bling-bling
D2	frosted, blurry, aeronautic, plastic, materials and texture
D3	a bit bright silver, more brighter, not very reflective
D4	similar feeling as D-1,reflect less light, warm, more expensive
D5	foggy, peaceful, going to die, feel die, dying naturally
D6	metal, harder than D1,metal for kitchen stuff, pot
D7	silver, not bright, not reflect
D8	bright, modern, cutting-edge, technology, business, business website, efficient, good

Table 7: Language use in response to sample D2 by design participants.

C1	lighter silver, not pewter, matte, opaque, almost transparent, mirror, same thickness as D1
C2	very smooth, white, not reflective, very even
C3	more of an even pigment, a lot brighter, brighter silver, more matte
C4	glossy, white mixed with grey, not shiny, mirror
C5	reflective, silver, matte, less clear
C6	silver, metallic, matte, opaque, fogginess
C7	velvet coat, nail polish effect, mirror, matte, metallic silver paint, car
C8	reflective, doesn't have a mirror effect, matte, gradient light grey, jewellery, kitchen stainless steel

Table 8: Language use in response to sample D2 by chemistry/engineering participants.

Range of semantic fields

As mentioned above, design participants express their feelings and emotions more than chemistry/engineering participants. The concept of the semantic field borrowed from linguistics is helpful here. Semantic fields is defined as "one way of imposing some order on vocabulary is to organise

it into 'fields' of meaning. Within each field, the lexemes interrelate, and define each other in specific ways" [9]. Design participants used a wide range of sematic fields creatively and imaginatively in their description. They used semantic fields of natural and artificial features, feelings, emotions, food, cities, country, nature, products, and temperature. In contrast, participants from a chemistry/engineering background used a more limited range of semantic fields focusing heavily on colour and surface.

Traditionally, scientists tend to value objectivity and methodological precision, whereas designers and artists tend to value creativity and might express their ideas more subjectively. Language used by design and chemistry/engineering students probably reflects the emphasis and values within their different disciplines.

Focusing on and describing colours in detail

It was observed that chemistry/engineering participants tend to make an objective observation to describe colours looking at it from different directions and positions. They described the name of colours repeatedly. This may also relates to semantic fields. Although participants from chemistry/engineering used limited range of semantic fields, they used vocabulary that showed fine-grained colour terminology within those semantic fields. These characteristics were clearly revealed by participants C1, C6 and C8 (Table 9). However, none of the design participants showed this verbal behaviour.

Participant	Sample	Description
C1	A-2	So A2 has a slightly *more red* tinge. So I would say it's still an *orange*, but it's a *slightly redder orange*.
	B-1	I would say it's an *off white* colour. It's more, it has a *blue tinge*.
	C-1	It's a *maroon purple* colour. I'd say *purple*, a lot *more purple*.
C6	C-2	It is a matte sort of *brown tan* colour. So *in-between brown and orange*, bit *more to the brown side*. It doesn't seem to reflect a lot of light and it's quite opaque.
C8	B-1	It's, *off white or white*. It's a *kind of white with a grey tint* to it. Or really *grey* if you're talking general terms. Relative to the stand though it appears a lot *closer to white but not white*, if that makes sense. Or not a *perfect white*.
	C-2	I would describe this as like a kind of a *rust colour*. *Kind of orangey, well slight orange but mostly brown*.
	F-2	It's like a *mix between gold and bronze*. Because I wouldn't say that it's like. It's *not a yellow gold* but it's more of a like *bronzy gold* or maybe, *not quite rose gold* either. It's got striations going horizontal, so you kind of see like little lines, and the various lines kind of show different vibrancy or saturation of that *gold*. So some parts of it look a bit, almost *darker gold, almost brown*. Whereas the places where it's highlighted appear *more gold brown*.

Table 9: Examples of fine-grained colour terminology by chemistry/engineering participants.

Expression of personal preferences

Five out of eight design participants expressed their personal preferences toward samples (Tables 10 and 11). It was observed that they tended to express their personal preference after they described their feelings and emotions. They also linked colour samples to their personal belongings. In contrast, only one person (participant C3) from chemistry/engineering showed a preference for a sample. However, his response was relatively short in comparison with design participants.

Disciplinary background	Design	Chemistry or Engineering
Terms used	Frequency	
I like	10	1
I do not like	10	0
Total	20	1

Table 10: Frequency of preference terms.

Participant	Sample	Participants responses
D1	F-1 and F-2	Wow, I like both, I like both, my favourite colours.
D3	F-2	I want to use this colour to decorate my home.
D4	A-1	I like the previous one more.
D7	E-2	I don't like this colour for jewellery.
D8	A-2	It makes me something fail or something unfortunate thing. I don't like this.
C3	F-1	It's a nice colour. I like this.

Table 11: Examples of extended preference expressions.

Describing how to change one sample to the other

In terms of describing how to change the first sample in a pair to look like the second, design participants often ignored this question. Some of them focussed on differences between samples and their own feelings instead of a practical method of making samples the same. On the other hand, all of the chemistry/engineering participants explained how to make the sample in each pair match. The terms used by them to answer this question contrasted with the responses of design participants. The chemistry/engineering participants used technical terms and explained the process systematically using fine-grained terms to distinguish between colours and materials (Table 12).

Participant	Sample	Description
C7	Changed sample F-1 to F-2	Um, first I need to have something like a sandpaper to scratch from in the surface one side to another side, so I can make this kind of structure. And then I probably going to spray of the like a gold paint on the top of it. Um or I can, ok there is a very scientific way of it. Because I can see this one is probably copper, so this one probably another kind of iron base metallic, so there is one of the ways that you put in different sign of the power like plus (+) sign and minus (-) sign, and you put the metal inside, because there is an aluminium, like a copper aluminium inside that solution so they will cover the top of it like that.
D1		Wow, I like both, I like both, I wouldn't change. Umm changes from here to there, can I touch? I will still do same thing, I would get a spray which is glossy and of a goldish (spray to F2) yes, yes, it's a very smooth one, that will bring the same like texture, yes, wow this is my favourite colour.
C8	Changed sample A-1 to A-2	Well if I'm using paints I would add a little bit of red into A1. Light, I would say red but I know that would absorb some of the reds wavelengths but I'm not sure. I would say paint wise I would say adding a bit of red. A2's a bit darker so in lights I guess I would make A1 a bit darker.
D7		Actually, A1 is more brighter than this A2, So I like A1. And When I choose one colour, I want to choose this one A1, yes.

Table 12: Example sentences of colour changes.

Suggestions for possible application of samples

Participants from a design background also described samples in terms of possible application (Table 13). This characteristic of design participants may be related to their creative role and behaviour in real life. Professional designers, for instance, can aid consumers in finding the direction that they wish to

follow, when customers do not actually realise what is achievable [10]. In contrast none of the participants from chemistry/engineering suggested applications.

Participant	Sample	Possible application
D2	E-2	Packaging design especially the luxury brand.
D3	C-2	Maybe this is good for clothes.
D6	F-2	It makes me feel like the package for the wine kind of.
D7	B-1 & -2	When I design for ... sophisticated design, I will use that kind of grey colour, um, yes.

Table 13: Possible applications suggested by design students.

Trying to touch (behavioural characteristics)

Various scholars claim that moving the body in natural ways and touching things help the way participants engage emotionally with tasks and affects how what is being evaluated is perceived [11-13]. It was observed that three out of eight design participants tried to touch or asked to touch samples although they were asked not to (Table 14). However, they described samples as if they had touched them. In contrast, none of the participants from chemistry/engineering ask to touch samples.

Participant	Sample	Participants responses
D1	F-1 & F-2	Can I touch? It's saying to me touch me.
	B-1	I want to even touch and feel that texture.
D5	B-1 & B2	I don't know I can touch it, because this textile, horizontal it makes me peaceful.
D6	E2	If I touch, the feeling like, I look at it, I feel something in my hand.

Table 14: Design participants' behavioural characteristics.

Conclusions

The main focus of this research was to investigate differences in colour communication between participants from the disciplinary backgrounds of design and chemistry/engineering. A number of contrasts have been revealed between them. The examples of language use collected in this study provide evidence that people from a design background use more varied and wide-ranging vocabulary than people from a scientific background. Also, design participants tend to react to samples with images and adjectives describing their feelings and emotions. For these reasons, they use evocative, emotional, and associative terms which are also related to use of a wide variety of semantic fields. They were likely to express their personal preferences as well as possible suggestions for products in real life.

On the other hand, chemistry/engineering participants focused heavily on colour and surface objectively. Compared to design participants, although they used limited sematic fields, they used more precise language in their description and a large number of terms with fine-grained distinctions. In terms of describing how to change one sample in a pair to the other, design participants often ignored this task, while chemistry/engineering participants used technical terms and explained the process systematically.

These differences may be one of the main reasons for communication problems between these groups when they collaborate in a professional colour specialist context. Although these differences and difficulties fade as time passes, it is not a rapid process. It may be worth considering how time can be saved in allowing them to understand each other better.

It is important to understand how people from different backgrounds describe and react to colours in different ways. This study may be a valuable resource to make people understand differences in the use of colour language. Moreover, there may be a need for learning sessions to help each group to understand the other's way of describing colour. This is because designers and colour scientists do need to work together to create products, and it is almost impossible to turn designers' intangible imagination and feeling into visible colour without technical support. However, this is not to say that differences among these groups should be totally removed. Both groups may value and find creativity in their different ways of expressing themselves.

The comparisons given in this study are not intended to suggest negative or positive judgements by the researchers but to describe the different values of these participants. The results of this research offer additional ways of understanding different approaches in describing colours. It is acknowledged that this paper has been written from a design perspective rather than a scientific one. This may have influenced our approach and stance and it would be interesting to know how a scientist colourist would have interpreted these findings. The research certainly provides justification for further study of communication between colour-using professionals in the work place. It is hoped that this will be a way of saving time in gaining mutual understanding, instead of professionals having to learn through experience.

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