Design of the MSc degree in Colour Technology for the Automotive Sector

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Abstract

In the worldwide automotive sector, production of new cars involves at visual appearance level a continuous challenge to assure the visual harmony of car bodies, both colour and texture attributes, in particular in automotive coatings formulations based on special-effect pigments with attractive visual effects based on goniochromism (colour change due to variations in irradiation and viewing directions). It needs new knowledge and competences for controlling complex instrumentation and visual assessment of colour and texture differences, both for interior and exterior parts of a car. From the University of Alicante, for the academic year 2014-15, we are organizing the first MSc degree in Color Technology for the Automotive Sector, with a design of contents embracing colorimetry and visual appearance, instrumentation and color management software, fundamentals of coatings and plastics in the automotive sector, etc, mainly aimed to professionals, undergraduates and graduates in chemistry, physics, engineering, etc. The MSc syllabus, with 60 ECTS, is designed to be taught in two semesters. Firstly, from September to February, in virtual or semi-attendance mode and by Moodle platform, theoretical and practical learning activities, finally combined with an intensive period of mandatory laboratory practices and invited technical conferences before starting the internships from March 2015. And secondly, from March to June, at virtual level, only internships and the MSc Thesis. Therefore, the MSc Thesis would be the performance report during the internship in companies or research institutions. Some multinational companies, both as car makers and coatings and plastics providers, from European and non-European countries have already shown their support and interest in welcoming students for specific training, even some job offers when the first MSc edition finishes. We therefore hope that this new Master, unique in its design and organisation, and well tuned with some specific industry needs, and placing to the University of Alicante in the global vanguard of the training of new inter and multi-disciplinary professions in the XXI century, can suppose a great encouragement and outreach to improve the employability of professionals and high quality graduates and increase the scientific-technological advances and profits in many industrial sectors (automotive, cosmetics, plastics for electronic consumers, printing inks, etc).

Keywords

Color Technology, Automotive Coatings, Internships, Design Thinking, University-Business cooperation.

1 Introduction

The University in Spain, and at worldwide, is being transformed in a rush, and perhaps without realizing ourselves (Barber, Donnelly, Rizvi, 2013). In our country, but also in other EU countries, it is obvious how the economical crisis affects the budgetary and financial sustainability of our Universities (Sterling, Maxey, Luna, 2013). Therefore, any Spain and European University (Araque, 2009; Pérez, Estermann, Bennetot, 2011)

should consider as soon as possible at strategic level which logistic, instrumental and human resources have and can quickly develop to undertake and diversify successfully capturing of new revenue from not public sources (Estermann, Bennetot, 2011; Hussey, Smith 2010; Attanasio, Capursi, 2011; Rondo-Brovetto, Saliterer, 2011).

In this sense, and relying on the three conceptual missions of the University, it always seems a good choice for each university to encourage, develop and consolidate their own postgraduate degrees, mainly for high professional specialization, promoting successfully the employability of our graduates anywhere of our planet. However, due to globalisation in recent decades, companies have evolved (Murmann, 2003; Davey, et al., 2011; UIIN, 2014), as well as industrialised and emerging countries, and everything quickly changes at an uncertain and high rate, but unstoppable, the European University should not continue from afar, but to analyse continuously from an institutional point of view of competitive intelligence.

The concept of work, in your attendance and virtual modes, or part or full time, etc, is also changing, and everything under the globalisation stream (Barber, Donnelly, Rizvi, 2013; Gratton, 2011; IPR-Bath 2013; Tomlinson, 2012). And in this sense, Universities should also be raised how to best ensure the employability of their graduates and postgraduates, both conventional and innovative profiles (OECD, 2011; Avis, 2010), but not only at regional or national level, but global (Barber, Donnelly, Rizvi, 2013; IPR-Bath 2013; Gratton 2011; Figuereido, et al, 2013; Montenegro, Pujol, 2013).

Following this argumentation, and without going into a pluralistic, constructive and synergistic discussion of common interests between supporters and critics of each of the three sub-missions of the University according to Ortega & Gasset (1930), or supporters of all of them, and some innovative ones not covered beyond the mid-twentieth century, this work focuses on a new design example and articulation, or implementation, of a new postgraduate course with high professional specialisation at worldwide, and that it would project, if was successful in its first class (to be shown in another work within a year, with their strengths and weaknesses, and improvement actions), the University of Alicante at the global vanguard of the training of new inter and multi-disciplinary professions in the XXI century.

2 Contextual origin of this Master

Colour technology focuses on the study of theories and techniques related to the design, manufacture and measurement of coloured materials (OpenCourseWare UA, 2009). A wide range of different industrial sectors are involved in colour technology (colorants, coatings, textiles, ceramics, plastics, printing, multimedia, etc.). Unfortunately, in many cases, colour experts within these sectors have not received any specific training in colour science. Therefore, their knowledge about colour, which is critical to develop their work, has been obtained through practical, possible self-taught, experience.

For this reason, companies involved in these productive sectors often invest considerable resources in specific colour training to improve their employees' skills. In the same way, the limited number of graduates having previously done advanced colour training is highly sought after by many companies.

Over recent decades, colour measurement and colour quality control of gonio-apparent materials have become key areas for the automotive industry (BYK-Gardner 2014) and also for other sectors such as cosmetics, coatings, plastics, printing, textiles, architecture, etc. Therefore, it is necessary to count on in-depth knowledge of complex instrumentation techniques and visual evaluation procedures as regards differences in color and texture (sparkle and graininess); and even color formulation with solid and special effect pigments (OpenCourseWare UA, 2009; BYK-Gardner 2014; Pfaff 2008; Streitberger, Dössel, 2008; Poth, 2008; Klein 2010).

In response to this socio-economic demand, the Colour and Vision Group of the Department of Optics, Pharmacology and Anatomy at the University of Alicante, in collaboration with other Spanish institutions (University of Granada - UGR, Technical University of Catalonia - UPC, Technical University of Valencia – UPV, and High Council of Scientific Research - CSIC) and different companies (AUDI, SEAT, BASF Coatings, BYK-Gardner, Mercedes Benz, Volvo, Toyota Motor Europe, PPG, Merck, Valspar, Plastic Omnium, Nubiola Group, etc), is offering the Master's Degree in Color Technology for the Automotive Sector (acronym: ColTAS) as a postgraduate course with 60 ECTS or credits (Figure 1).



Fig. 1: Logo of the MSc degree in Color Technology for the Automotive Sector.

3 Mission, competences and objectives

The purpose of ColTAS Master is to provide comprehensive training in the multidisciplinary study of Colour Science and Technology from a global perspective. Students will learn the physicochemical and visual laws and solve real or simulated problems that often arise when using special effect pigments in different industrial sectors, particularly within the automotive sector (Figure 2).

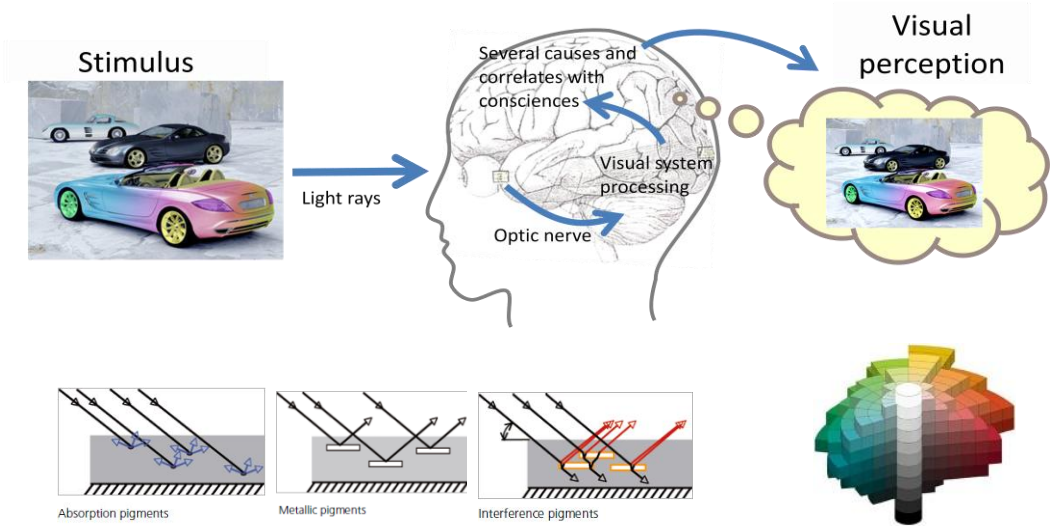


Fig. 2: Light-matter-eye (brain) interaction at nano-micro (structural, left) and macroscopic (perceptual, right) level.

This course includes an industry-based internship of up to 300 hours and provides a great opportunity to achieve basic and advanced colour control skills at an industrial level, particularly in the automotive sector.

For colour experts with, or not, a university degree, this new postgraduate course is a great chance to enhance training and professional qualifications. Meanwhile, recent graduates, even undergraduates as it will be shown below, who choose to undertake this specialist postgraduate course will find it easier to obtain highly specialized jobs, which are therefore more highly valued (and better paid).

From the skills demanded by the industry, a series of contents and learning objectives intended to meet the following competences has been planned as follows:

3.1 General Key Competences (GKC)

GKC1: Acquire advanced knowledge and skills in the field of Colour Science & Technology;

GKC2: Ability to critically trace and understand the last scientific-technological advances related to the special-effect pigments in some industrial sectors, particularly in the automotive sector;

GKC3: Ability to link knowledge and skills enabling to tackle problems from different views, enriching the solutions;

GKC4: Ability to carry out guided research or innovation works on the quality management of the visual harmony in cars at an advanced level;

GKC5: Develop originality and creativity when some specific colour technology problems applied in some industrial sectors (automotive, cosmetics, architectural coatings, design, et.) should be tackled.

3.2 Transversal Key Competences (TKC)

TKC1: Skills of writing and oral communication in English and Spanish. Capability of making and advocating reports and projects;

TKC2: Skills related to computer tools and ICTs, as well as database online access, scientific literature, patents and standards;

TKC3: Skills of adaptation, planning and organization in quality and effective making of autonomous works or inside interdisciplinary teams in front of new and / or real situations;

TKC4: Skills of leadership for taking sustainable, responsible, ethical, committed, consensual and efficient decisions.

3.3 Cognitive Key Objectives (TKC)

Therefore, the learning objectives would be structured as follows:

CKO1: Understand the physic-chemical causes of colour as a result of the light-matter-eye interaction;

CKO2: Control the mathematical foundations of the encoding and graphical and numerical depiction of colour and texture by the human visual system;

CKO3: Understand and know-how to measure the visual and optical properties, either normal or special (luminescent, goniochromatic, textured, functional, etc), of any material;

CKO4: Acquire a general view of the types of dyes and pigments (Klein 2010, Pfaff, 2008), either organic and inorganic, with normal or special / functional behavior, and their industrial applications (Figure 3);

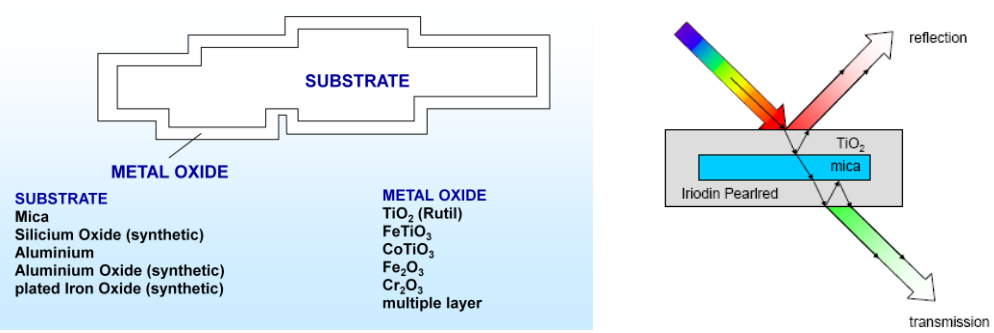


Fig. 3. Scheme at nano-micro scale (left) of pigment particles with goniochromatic effect, and its perceptual and optical effect (right).

CKO5: Acquire a general view of the raw materials involved in coatings and plastics used in the automotive sector (Streitberger, Dössel, 2008; Poth, 2008), as well as their systems and application processes for special-effect pigments (Figure 4);

CKO6: Understand the perceptual foundations of lighting and colour in order to efficiently manage the quality control of the visual harmony in the automotive sector;

CKO7: Know and compare the current methods of coloration technologies, either conventional (textile, coatings, plastics, etc) and digital (displays, printing, etc), or any innovative other;

CKO8: Understand and adapt algorithms for effectively encoding and transforming of the visual and chromatic information among multimedia devices (capture, visualisation, etc) and its linking with the digital management of formulation and visual quality of gonio-apparent materials (Figure 5).

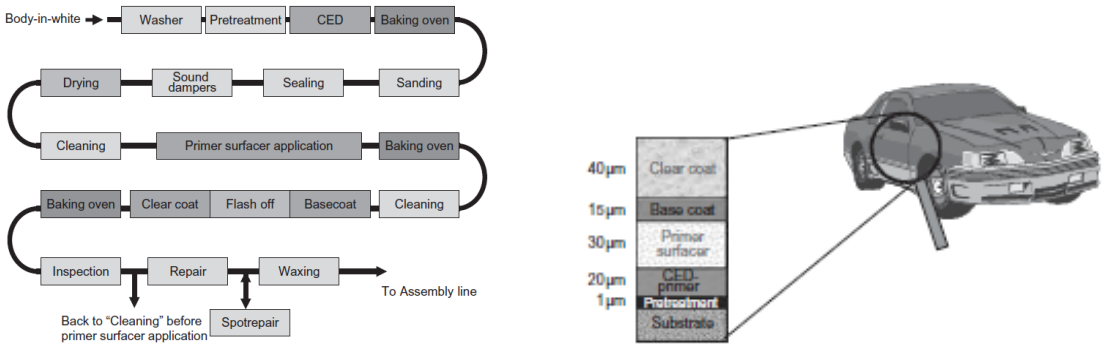


Fig.4. Steps of the conventional industrial process of painting of the car body (left). Micro cross section of OEM coating layer of a car (right).



Fig. 5. Example of a colour harmony failure in the frontal side of a car (left); visual comparison in colour, gloss and texture of a sample pair inside a diffuse lighting booth (right), with some colour devices (from left to right: multi-angle spectrophotometers BYK-mac and X-Rite MA98, and the gonio-vision-box).

3.4 Procedural Key Objectives (PKO)

PKO1: Measure, calculate and graph the visual (colour and texture) appearance of materials, either opaque, goniochromatic, fluorescent, etc, associated with many industrial sectors;

PKO2: Calculate and graph the colour difference among objects (light sources, opaque or translucent or goniochromatic materials, etc), even images, and their industrial tolerances (i.e., ΔE AUDI2000, based on the CIE-L*a*b* colour space);

PKO3: Characterise any type of colorant (dye or pigment), either normal or special-effect, and material able to be colored to be used in any system of color formulation.

PKO4: Solve the colour recipe enabling, with the controlled mixing of some colorants, on a material or substrate, to match the reference colour of a previously characterised material (Klein 2010);

PKO5: Design and implement psychophysical experiments with real human observers using adequate lighting booths which efficiently manage the visual and instrumental correlation of gonio-apparent materials in many industrial applications;

PKO6: Integrate and weigh the texture and colour properties of gonio-apparent materials to control the visual harmony of interior and exterior parts of cars (Figure 5);

PKO7: Control some commercial reference softwares in the automotive sector for management of the texture and colour quality;

PKO8: Experiment with and apply quality control tests with the different systems and processes for special-effect pigments in coatings and plastics usually applied in the automotive sector.

4 Syllabus, teaching strategy and evaluation methods

This Master of 60 ECTS or credits (one academic year, from September to June) is managed by the Continuing Education Centre (CEC-UA), and organised by the Business School of the General Foundation of the University of Alicante and the Department of Optics, Pharmacology and Anatomy, belonging to the Faculty of Science of this University. The syllabus, taking into account the competences and learning objectives shown above, is composed by the following subjects distributed in two semesters (Table 1): first, up to February, for applied and theoretical training, and, second, for only the internships and MSc Thesis.

Table 1. Syllabus of the MSc degree in Colour Technology for the Automotive Sector, with options to cover some sub-degrees in different academic years for undergraduate students and professionals without University degree.

DEGREE DISTRIBUTION	SEMESTER	SUBJECT	ECTS
Expert in Colour Science	1	Basic Colorimetry	6
	1	Colour Perception	6
	1	Colour Physics and Chemistry	6
	1	Bibliographic Resources	2
Specialist in Colour Engineering for the Automotive Sector	1	Advanced Colorimetry	4
	1	Visual Appearance	6
	1	Visual Harmony Management	5
	1	Coatings and Plastics	3
	1	Colour Reproduction	7
	2	Internships I	5
MSc in Colour Technology for the Automotive Sector	2	Internships II	4
	2	MSc Thesis	6

As shown in Table 1, for undergraduate students (with less than 18 ECTS for finishing her/his graduate) and professionals without University degree, the ColTAS Master enables to obtain two sub-degrees (Expert = 20 ECTS + Specialist = 30 ECTS) before obtaining the final MSc degree, even in different academic years, obtaining the corresponding qualifications signed by the University of Alicante President.

The teaching methodology will be the b-learning (blended learning) by the Moodle platform (http://si.ua.es/moodle), with individual and collective learning activities, with a weekly continuous and effective communication and tutoring between student and professor. However, taking into account the applied profile of this Master, when the first semester will be finishing, and before starting the internships, there will be an intensive period of mandatory laboratory practices and invited technical conferences (workshop).

Therefore, classroom attendance is not mandatory, except the mandatory attendance for laboratory sessions and workshop finishing the first semester. But the virtual learning activities will be diverse and demanding. These activities will be evaluated to guarantee the assimilation of general, transversal, cognitive and procedural skills. If students do not fulfill the established requirements, they will simply receive a certificate of attendance.

The Master's thesis in June will involve drawing up, presenting and defending a report on the activities undertaken during the industrial internship (car manufacturers, coatings and plastic suppliers, etc., from March to June) or at a research institution. To do this, several companies of national and international prestige inside and outside of Spain will host ColTAS students for a period not exceeding 300 hours in the second semester (spring), and where the development activities can be conventional or RTD, always demanded and coordinated by the company and ColTAS guidance. Moreover, any professional could do the internship in her/his own company, provided that a formal agreement between the company and University of Alicante is previously signed. Exceptionally, some companies will offer freely some scholarships and grants for some ColTAS students. The ColTAS director will try to accommodate the preliminary interests and preferences of students and companies. The period for receiving without cost new company collaborations will be always open. The official ColTAS website is in http://www.enegocios.ua.es . Additionally, there always will be more information from the website of Colour & Vision Group: http://web.ua.es/en/gvc .

The ColTAS teaching staff includes professors and researchers belonged to the University of Alicante, but also from other Spanish Universities (UPC, UGR, and UPV) and research centers (CSIC), and professionals currently associated with the automotive sector (AUDI, BASF Coatings, BYK-Gardner, Merck, AkzoNobel Coatings, etc).

5 Entry requirements, fees and registration

The ColTAS curriculum is mainly intended for graduates in chemistry, materials, chemistry, industrial engineering, physics, optics, imaging science, computer science, mathematics, or any discipline pertaining to the quantitative description of colored materials, with a intermediate knowledge in spoken and written English. But, obviously, it is possible to access to this Master as undergraduate student, or professional without University degree, provided that the „Expert" + „Specialist" combination is done, even though in different academic years. For any general information regarding registration,

legalisation of documents, foreign students, scholarships, insurance and issuance of degree certificates it is convenient to contact with the Continuing Education Centre (CEC-UA: http://web.ua.es/en/continua/continuous.html).

The ColTAS registration fee is €4200 to be paid by installments (corporate registration available), taking into account a price of 70 €/ECTS. Anyone interested in registering should complete a pre-registration form before 30th June 2014 available in the official website. This form is also available from the course Secretary and must be handed in with a photocopy of the student's National Identity card or passport, as well as any academic transcripts and degree certificate/s. During the first half of July 2014, the Head of Studies will publish the list of admissions, which will be formalised once payment of the course deposit fee (€420, equating to 10% of the total course fee) has been confirmed in the CE-UA's Sabadell Bank account. This payment constitutes part of the first installment of the fee and will be deducted from the first installment in September.

Generally, those accepted onto the course will be required to pay course fees to the CEC-UA in three installments, the first one in September 2014 (50%), the second in November 2014 (25%) and the final installment in April 2015 (25%). However, spite of having adjusted fees according to the great opportunity of employability and professional progression in an worldwide strategic industry sector for next decades, the advertising campaign, even using social networks as Linkedin, etc., has not got enough interest yet for potential students (chemistry, physics, engineering, etc.) to start the first edition in the academic year 2014-15. But, we hope to strength this initial weak point with the support of our University, Universia, etc.

6 Conclusions

The MSc degree in Colour Technology for the Automotive Sector (ColTAS) of the University of Alicante (Spain) is inter and multidisciplinary one-year course covering very innovative areas such as colour measurement & perception, visual appearance of texture and colour, colour quality management & formulation of special-effect pigments applied in the automotive sector, as well as in other industrial sectors as cosmetics, plastics, etc. The programmed objective is to train students in advanced methodologies and models in colour science and technology focused on gonio-apparent materials. With a perfect mix of relevant theoretical and practical knowledge, reinforced with internships in company, ColTAS post-graduates will be in the position to join major companies in the automotive sector, both car makers and their coatings providers, or even in other industrial sectors (pigment producers, cosmetics, etc).

We therefore hope that this new Master, unique in its design and organization, and placing to the University of Alicante in the global vanguard of the training of new inter and multi-disciplinary professions in the XXI century, can suppose a great encouragement and outreach to improve to improve the employability of professionals and high quality graduates and increase the scientific-technological advances and profits

in many industrial sectors sectors (automotive, cosmetics, plastics for electronic consumers, printing inks, etc).

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