

DESIGN OF ONLINE PRACTICAL LESSONS IN COLORIMETRY

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Abstract

Applied colorimetry is an important module in the program of the elective subject "Colour Science: industrial applications". This course is taught in the Optics and Optometry Degree and it has been used as a testing for the application of new teaching and assessment techniques consistent with the new European Higher Education Area. In particular, the main objective was to reduce the attendance to lessons and encourage the individual and collective work of students. The reason for this approach is based on the idea that students are able to work at their own learning pace. Within this dynamic work, we propose online lab practice based on Excel templates that our research group has developed ad-hoc for different aspects of colorimetry, such as conversion to different colour spaces, calculation of perceptual descriptors (hue, saturation, lightness), calculation of colour differences, colour matching dyes, etc.

The practice presented in this paper is focused on the learning of colour differences. The session is based on a specific Excel template to compute the colour differences and to plot different graphs with these colour differences defined at different colour spaces: CIE ΔE , CIE ΔE_{94} and the CIELAB colour space. This template is implemented on a website what works by addressing the student work at a proper and organized way. The aim was to unify all the student work from a website, therefore the student is able to learn in an autonomous and sequential way and in his own pace. To achieve this purpose, all the tools, links and documents are collected for each different proposed activity to achieve guided specific objectives. In the context of educational innovation, this type of website is normally called WebQuest. The design of a WebQuest is established according to the criteria of usability and simplicity.

There are great advantages of using WebQuests versus the toolbox "Campus Virtual" available in the University of Alicante. The Campus Virtual is an unfriendly environment for this specific purpose as the activities are organized in different sectors depending on whether the activity is a discussion, an activity, a self-assessment or the download of materials. With this separation, it is more difficult that the student follows an organized sequence. However, our WebQuest provides a more intuitive graphical environment, and besides, all the tasks and resources needed to complete them are grouped and organized according to a linear sequence. In this way, the student guided learning is optimized. Furthermore, with this simplification, the student focuses on learning and not to waste resources.

Finally, this tool has a wide set of potential applications: online courses of colorimetry applied for postgraduate students, Open Course Ware, etc.

Keywords: Online teaching, lab practice, WebQuest.

1 INTRODUCTION

Applied colorimetry is a thematic module in the program of the course "Colour Science: industrial applications". This course is taught in the Optics and Optometry degree. It was used as a test for the application of new teaching and assessment techniques consistent with the immersion within the European Area of Higher Education (EAHE). In particular, the new trends to reduce the attendance to lessons and to encourage individual and collective work of students are shown in this work.

This course is proposed in an online way from 2008 through the "Campus Virtual", an internal tool provided by the University of Alicante what allows to create a platform with tutorials, discussions, tests, etc. In addition, a blog was particularly designed for this course. The reason for using this methodology is based on the purpose to allow the student to establish an own learning pace. Following this online methodology, online lab practices are proposed what are focused on Excel templates. We designed these practices for different aspects of colorimetry such as conversion to

different colour spaces, calculation of perceptual descriptors (hue, saturation, lightness), calculation of colour differences, etc.

The characterization of any colour can be treated in a mathematical way. Thus, different standard colour spaces have been developed to describe colours. Furthermore, colour differences formulae have been also defined to quantify colour differences between test and standard samples. This development has many applications in different industrial sectors [1-4]. For instance, in textile industry: when a manufacturer receives a production order, he should get a colour as close as possible to the sample of a catalogue (colour reproduction). This is an everyday process, for this reason everybody assumes that it is simple, but it is a complicated and hard process. For this case, the dye transfer is a chemical process that depends strongly on the boundary conditions, and it is not easily reproducible. Therefore, a battery of tests with a different dye concentration is often necessary to achieve a good colour reproduction. This colour matching can be measured visually, i.e. "by eye", or can be measured numerically through a colour difference formula. In a globalized world, with several important industrial groups that move 165 billions of Euros, the quality control about colour differences, it is becoming an area of enormous economic interest. Therefore, this topic is an important subject in this course and many efforts have been done to try that students understand the complexity of colour reproduction.

To achieve this purpose, different online lab practices were designed. In this paper, we present the practice related to the computation of colour differences.

2 METHODOLOGY

As said previously, a practice is proposed to learn and understand the concepts and calculations about colour differences. The practice is focused on an Excel template prepared for applying colour difference formulae and to plot them in standard colour spaces defined by the International Commission on Illumination (CIE) such as the CIELAB colour space. In addition, this template is implemented in a website designed for this course. The aim of this website is to unify all the student work from a website, thus the student can learn in an autonomous and sequential way, and following his own learning pace. The website collects all the tools, links and documents in each proposed activity to achieve a set of objectives in a guided way. This type of website is adjusted what in the Technologies of the Information and the Communication (ICT) is called a WebQuest.

A WebQuest is a learning unit which aims to build the student knowledge from information and resources found on the web. The WebQuest has a very characteristic structure. In general, all the WebQuests show the following elements [5-6]:

- INTRODUCTION: This section presents a problem and the student is motivated to do the proposed tasks to solve the problem.
- TASK: This section sets out clearly the objectives to be achieved and what tasks are necessary to do in order to achieve the objectives.
- PROCESS: This section is where all tasks are listed. All the activities are explained step by step.
- EVALUATION: This section contains a self-assessment in order to allow students to be clear what is expected of them. They can assess whether the objectives are achieved or not.
- CONCLUSION: In this section the student can draw the conclusions obtained after achieving the objectives by doing the proposed tasks. Different questions can be added to expand knowledge.

The WebQuest has been developed has another relevant section: frequently asked questions (FAQs). This section is not common on WebQuest but we consider that this section can be very useful for students:

- FAQs: In this section, a set of questions will be added. These questions are common doubts among students from other similar courses.

This WebQuest was designed as a work desk by collecting activities of a particular topic, previously worked through the "Campus Virtual" tool. The advantages of using WebQuests versus the "Campus Virtual" are significant. The "Campus Virtual" has an unfriendly environment and tasks are divided into different sectors depending on whether they were a discussion, an activity, a self-assessment or the download of materials. However, the WebQuest is a website with a friendly graphic environment, it is more intuitive and all the tasks and resources are organized according to a linear sequence. This will

optimize the student guided learning and the student time. Furthermore, this simplification helps the student focus on learning and not waste time to search information.

Therefore, our main propose is to simplify the working environment. To achieve this we define a set of guidelines for the development of the website:

1. Usability. The usability, or the ease of use, is one of the basic keys to an educational website. A simple website enables the student to focus exclusively on educational content. The website should be easy to use, and it cannot become a labyrinth for the student. Therefore, the website is presented in a clean and simple format. The access tabs are always on the left side and the student can access to all the contents with a single click and with a direct return to the home page.
2. Simplicity. We decided a website with a non-hierarchical linear structure of contents. Thus, the student is making progress in a constant and orderly way from one tab to the next one. All tabs follow a continuous by defining a way.
3. Compatibility with simple applications. We decided to use simple and well known software. The materials are in pdf and xls files; these formats are not free but they are the most common and accessible from free software as Open Office or PDF reader. Firstly, we considered develop the website to work with free software (Open Office or Lotus Symphony) but finally we decided to use Microsoft programs because they are more widely distributed. Furthermore, this software is installed in all the computer rooms at the University of Alicante. Thus, students can open the files and to save in a different format depending on their needs.

Following this guideline, we designed a website. The Fig. 1 shows the main page of this website. The format is simple, classic and clean colours. A bar with a series of tabs is found in the left part to guide the student throughout the session. On the right side, the contents of the selected tab are presented, which basically correspond to the sections described above.

- Introduction: It raises a series of questions intended to motivate students and to define the background. In addition, the objectives what it is supposed that the student will achieve are summarized in this section.
- Task: The list of objectives to be achieved by doing the three proposed tasks is presented.
- Process: This section is divided into three tasks. Each task has a specific purpose. Different activities are proposed in each task to help students to construct knowledge related to the calculation and analysis of colorimetric data.
 - o Task 1: This task is designed with the aim that student reviews the concepts of the learning unit, "Colorimetry". Some readings are recommended. The student is asked to answer a set of basic questions to make sure he knows the main concepts.
 - o Task 2: This task tries that the student knows the necessary measurements to characterize a colour. A specific activity is proposed to learn how to obtain the tristimulus values of a colour sample from physical variables that can be measured, such as the spectral power distribution. A excel template is provided to do these calculations. Thus, an activity is also planted to learn to manage this template.
 - Activity: A pdf file with a complete explanation about the use of the Excel template: what are the input parameters? what calculations are in each sheet?
 - Activity: A realistic problem is proposed about the computation of colour differences and analysis of results. This activity is focused on the industry textile.
 - o Task 3:
 - Activity: A pdf file with a complete explanation about the use of the Excel template: what are the input parameters? what calculations are in each sheet?
 - Activity: A realistic problem is proposed about the computation of colour differences and analysis of results. This activity is focused on the industry car.
- Evaluation: Self-assessment to be aware whether the objectives have been achieved. In addition, students are asked to answer a brief questionnaire with ten questions to evaluate their knowledge. The student has to obtain a minimum mark of 7. On the contrary, the student is asked to review the activities since the concepts are not clear.

- Conclusions: This section outlines the conclusions that the student should obtain at the end of this online practice. More activities and readings are recommended for those who want to go into the subject.
- FAQs: Frequently asked questions. This section is growing course by course with response to tutorials done by students.

Fig.1-4 show the general structure of this WebQuest. The different sections previously explained are shown.



Fig. 1. General structure of our WebQuest. The menu is on the left and the content of the section “Introduction” is shown in the centre. Firstly, the problem is shown with an individual reflection. Next, the main purpose is described.

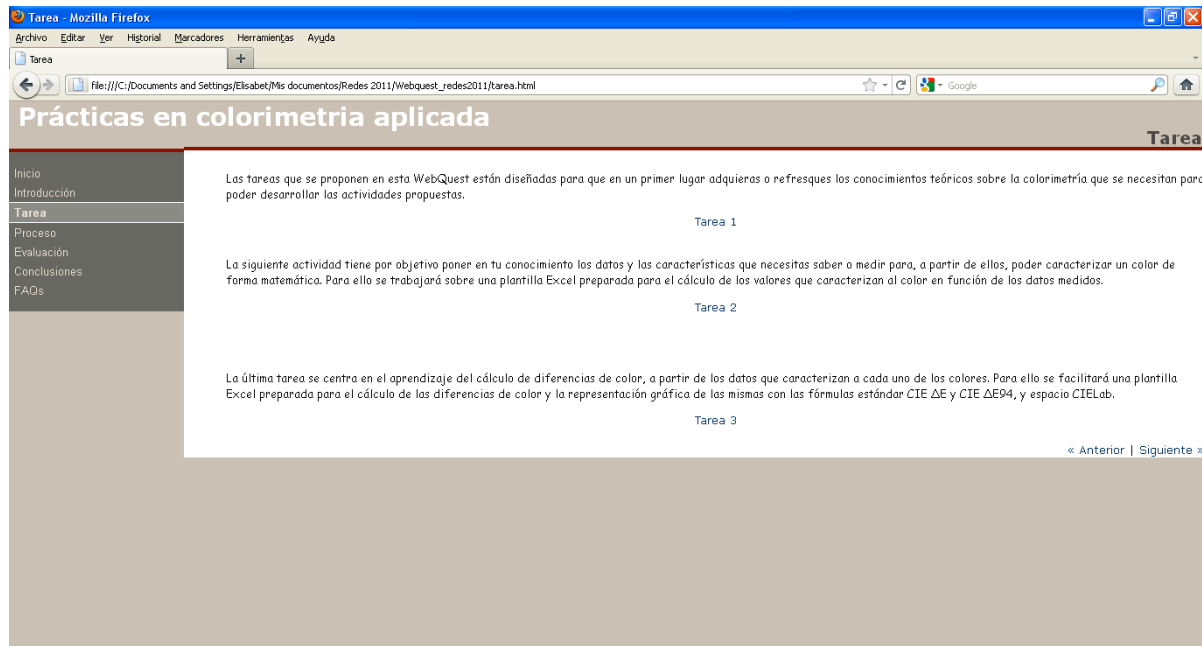


Fig. 2. General structure of our WebQuest. Three different tasks are proposed to the student. The first task is a review of the main concepts about applied colorimetry. The second task is about the calculation of the tristimulus values with an exercise related to the textile industry. The last task is an exercise related to the car industry.



Fig.3. Task 3: computation of colour differences by using an Excel template. The calculations in the Excel file, after doing the activity 2, allow to the abstraction. The student is focused on understand the concepts by avoiding the difficult calculations with a manual calculator.



Fig. 4. Self-assessment. With this test, the student reflects on the tasks and the theoretical knowledge. The student should achieve a minimal mark (7/10) whether not; the student should review the concepts and tasks.

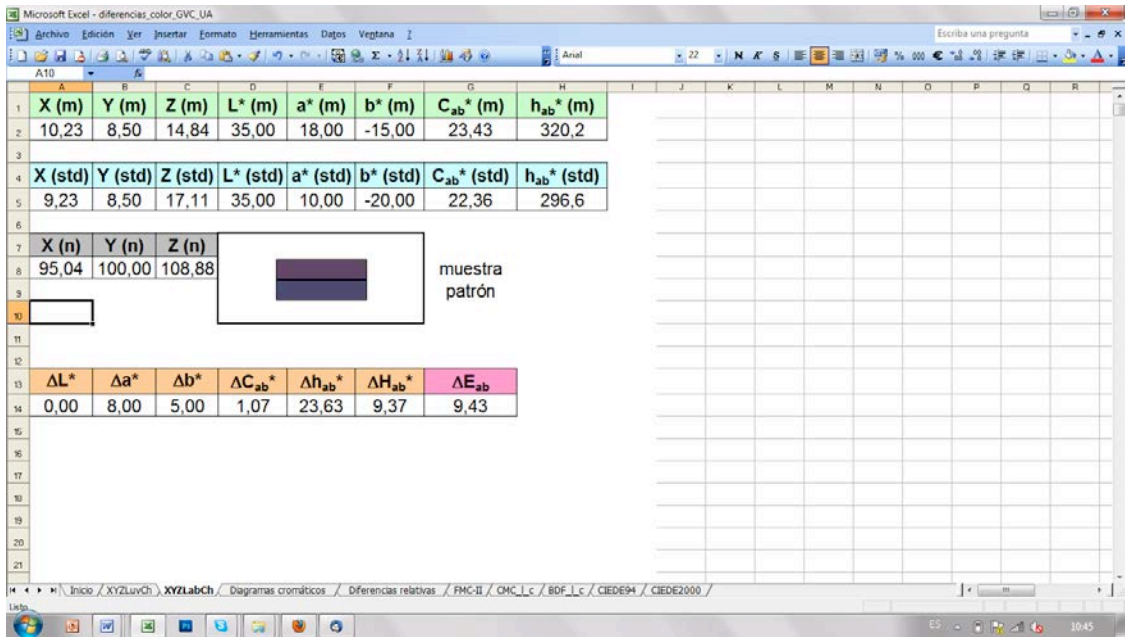


Fig.5. Technical aspects of the excel template about different colour difference formulae. The tristimulus values and the CIELAB data are computed from the spectral power distribution of a test and standard sample. Next, the CIELAB colour difference is calculated. Furthermore, the student can see the colour appearance of both sample and to do a visual judgement.

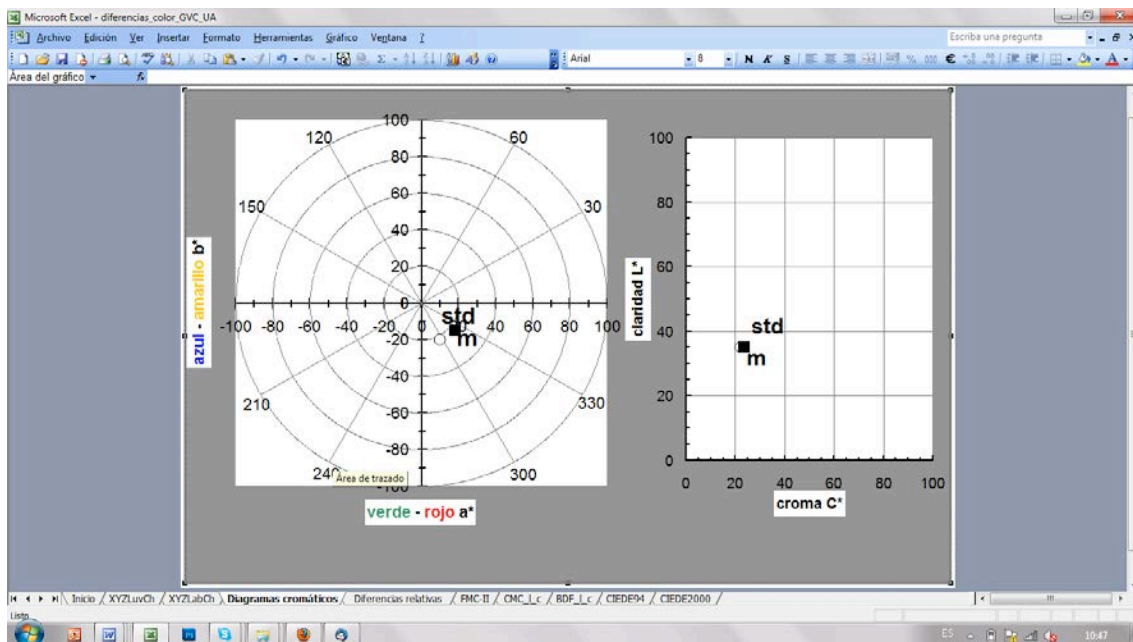


Fig.6. Technical aspects of the excel template about different colour difference formulae. The chromatic diagram b^* vs. a^* and L^* vs. C^* are also plotted in this template. Therefore, the student learn about colour spaces.

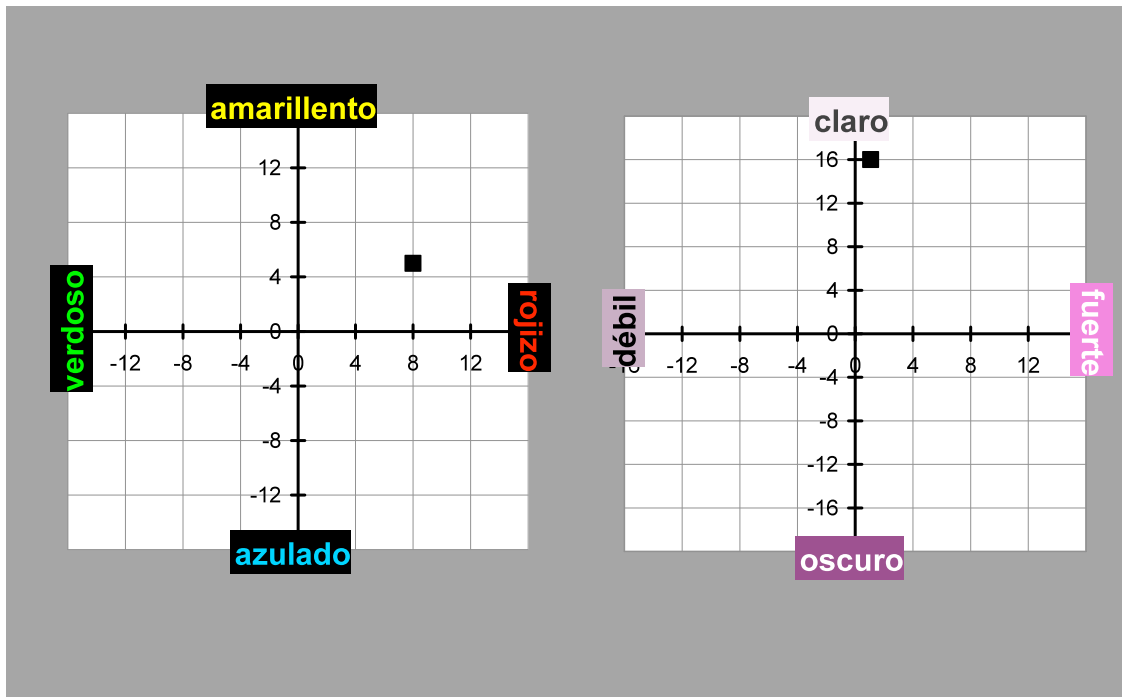


Fig.7. Technical aspects of the excel template about different colour difference formulae. The colour difference between the test and the standard sample is plotted in a chromatic diagram. In this way, the student can characterize the colour sample: For instance, the test sample can be darker or lighter than the standard sample. The test sample can be more greenish or reddish than the standard sample.

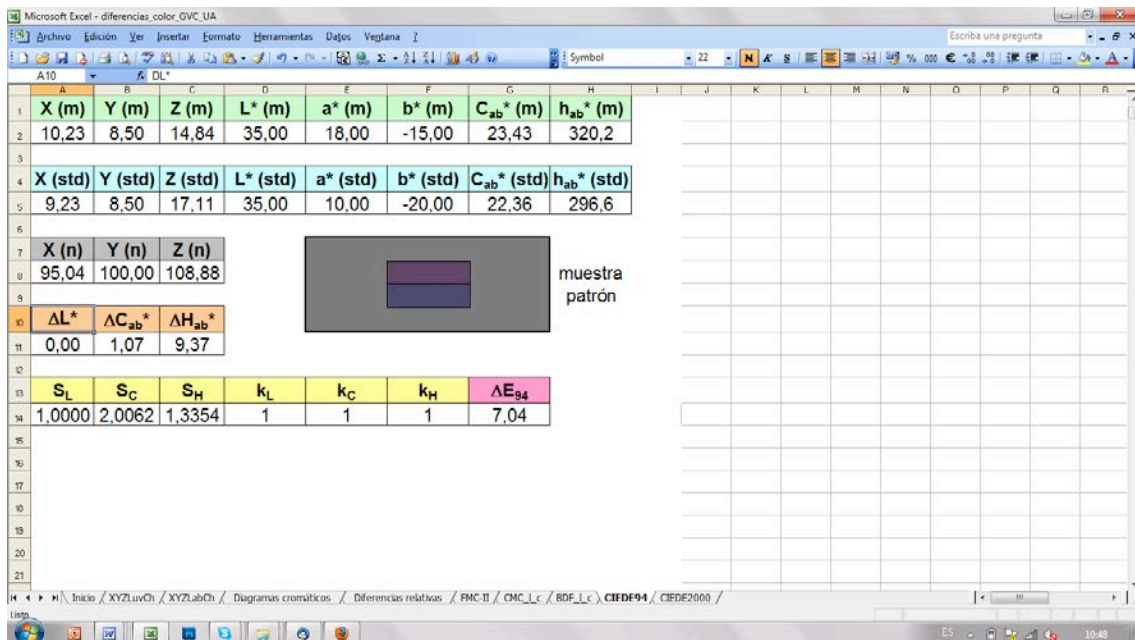


Fig. 8. Technical aspects of the excel template about different colour difference formulae. The tristimulus values and the CIELAB data are computed from the spectral power distribution of a test and standard sample. Different colour difference formulae are computed in the Excel file: CIELAB colour difference, CIEDE94 and CIEDE2000.

3 RESULTS AND CONCLUSIONS

The main conclusions are summarized below:

- A WebQuest was developed for studying applied colorimetry in order to reduce the attendance to lessons and to provide a useful tool for students to learn and understand important concepts by themselves.
- At the present time, we have fully developed a pilot practice about colour differences, but there are plans to extend the experience to other practices of this course. In the future, the course "Colour Science: industrial applications" could be an online course.
- The WebQuest has a fundamental advantage over "Campus Virtual". The environment is much friendlier by generating a single desktop and focused exclusively on academic proposal (in our case, applied colorimetry). The new Technologies of the Information and the Communication allow to develop new tools for students with more advantages about the traditional ones.
- The design of the WebQuest is set according to the criteria of usability and simplicity. For this reason, the WebQuest is a platform where the student can acquire new knowledge and to put in practice all the concepts with different tasks.

Furthermore, there are many potential applications of using WebQuest: online courses for industries about applied colorimetry, International Master of Vision, Open Course Ware, etc. Therefore, it is a very useful tool that opens new possibilities to share knowledge.

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