Webcams as a tool for teaching in Optometry training

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Abstract. Clinical Optometry lab training is devoted to develop the student’s skills needed in eye healthcare professional practice. Nevertheless, students always find difficulties in the management of some optometric instruments and in the understanding of the evaluation techniques. Moreover, teachers also have problems in explaining the eye evaluation tests or making demonstrations of instruments handling. In order to facilitate the learning process, webcams adapted to the optometric devices represent a helpful and useful tool. In this work we present the use of webcams in some of the most common clinical test in Optometry as ocular refraction, colour vision test, eye health evaluation with slip-lamp, retinoscopy, ophthalmoscopy and contact lens fitting. Our experience shows that with this simple approach we can do things easier: show the instrument handling to all the students at the same time; take pictures or videos of different eye health conditions or exploratory routines for posterior visualization with all the students; recreate visual experience of the patient during optometric exam; simulate colour vision pathologies; increase the interactions between students allowing them to help and correct each other; and also record the final routine exam in order to make possible its revision with the students.

1. Introduction
Clinical Optometry lab training is one of the pillars in the Degree in Optics and Optometry program. It is devoted to develop the student’s skills needed in eye healthcare professional practice. They should manage all the optometric instruments with ability and control the evaluation techniques. Nevertheless, students always find difficulties in this task, in particular for some eye evaluation tests. On the other hand, teachers also have problems in explaining the management of the instruments or making demonstrations of its handling.

In order to facilitate the learning process, webcams adapted to the optometric devices represent a helpful and useful tool. This system allows teachers to make demonstrations of instrument handling, to recreate visual experience of the patient during optometric exam, to record the student practice examination and to simulate colour vision pathologies, among others. Besides, our experience shows that this method increases students’ self-confidence and promotes interaction between them. In other words, they are able to see what a colleague is doing in the eye evaluation and they realize the errors committed and discuss about them.
We present in this work the use of webcams in some of the most common clinical test in Optometry. There are included ocular refraction, colour vision test, eye health evaluation with slip-lamp, retinoscopy, ophthalmoscopy and contact lens fitting [1-4].

2. Uses of webcams in Optometry lab
Following we explain the uses of webcams in different optometric test. We used an intermediate quality webcam model for all the tests, the Microsoft Lifecam HD-5000 connected to a PC running Linux, which reduces the cost of the setup.

2.1. Subjective refraction and refractive error simulator
The evaluation of refractive error is part of the usual optometry practice. Subjective refraction is the technique of comparing one lens against another, using changes in vision as the criterion, to arrive at the dioptric lens combination that results in maximum visual acuity. Optometrist uses trial frames or a phoroter combined with optotypes for this task [1].

In this experience we modified the webcam by removing its lens and adapting a 2.54 cm focal length lens with a variable aperture diaphragm. The modified webcam resembles an "artificial eye". The ametropies of the eye were introducing by modified its axial length or placing an ophthalmics lens before the diaphragm. Then the "artificial eye" was placed behind the aperture of the phoroter that the patient sees through. An observer interpreted the image provided by the webcam in order to performe the "artificial eye" refraction, using common procedure of subjective refraction with current Snellen optotype.

This experience was used to explain how the patient sees the optotypes depending on the ametropy and sees the optotypes during the different steps of the refraction protocol. As we said, with the aid of different ophthalmic lenses placed before the diaphragm we induced different refraction errors to the "artificial eye", and then a student executed the subjective refraction protocol, allowing the teacher to evaluate the ability of the student, by watching the images provided by the "artificial eye" (see in figure 1 three images provided by the "artificial eye" in three different steps of the subjective refraction protocol).

![Figure 1](image)

**Figure 1** Optotype cards seen thought the "artificial eye" during refraction. In (a) we can see how the "artificial eye" sees the optotype card in the refraction test with letters optotype and spherical lenses. In (b) the astigmatism is being tested with the clock test. The vision at the end of the refraction with the better correction is shown in (c)

2.2. Colour vision test
The pseudoisochromatic charts are the most popular colour vision test [1, 2]. They consist in a book with several charts; each one contains a number or figure, or even an irregular line. The figure is composed of points that differ from the background in tone and bright, this disposition tends to hide
the figure to those patients with a determined colour vision deficiency [2]. In order to show the visual experience of a patient with different colour vision deficiencies, we placed coloured filters before the webcam and evaluated a pseudoisochromatic chart test. That allow us to explain our alumni how patients with a colour vision disorder perceive the colours and why they fail the test. We simulated three chromatic deficiencies with red (protan), green (deutan) and blue (tritan) filters (figure 2).

![Figure 2](image)

**Figure 2** Ishihara´s test seen with the webcam without a filter (a) and with a red filter simulating a red-green deficiency (b).

### 2.3. Slit-Lamp management

Slit-lamp, also known as biomicroscope, is one of the most important tools in optometry practice. It is a low-power microscope consisting of an observation system, which is a binocular microscope; an illumination system, which is a bright light source with a mechanism that allows to control the width an orientation of the slit; and the mechanical support for its coordination [1-4]. The training in the use of the slit lamp has always been difficult for Optics and Optometry students. Instruments with associated cameras help a lot in this task. However, these devices are more expensive than those that do not have an integrated camera connected to a display unit.

With the aim to improve students’ skills in the management of slit lamp, we fabricated a device to adapt to one of the oculars of the slit-lamp, a webcam connected to a PC running Linux [5]. We used it to make demonstrations of an eye health evaluation routine and to control the student in its management (figure 3). Our experience shows that this simple method has several advantages. It allows us to take pictures with a good quality of different conditions of the eye health; we can record videos of eye evaluation and make demonstrations. It increases the interactions between students because they could see what their colleagues are doing and take conscious of the mistakes, help and correct each other. It is a useful tool for teachers for monitoring the exam of slit-lamp handling too. We think that the method supports the training in optometry practice and increase the student’s confidence without a huge outlay.

![Figure 3](image)

**Figure 3** Slit lamp webcam adaptor.
2.4. Direct Ophthalmoscopy
Ophthalmoscope is an instrument designed to view anatomical details of the human retina, it is composed by a light source, a moveable disc that held an assortment of lenses and a set of mirrors [1]. In this experience we adapted the webcam to a direct ophthalmoscope with the aim of making video recordings of an eye fundus exploration. That recording was used in class to show how retina is seen through this instrument and how to perform the eye fundus evaluation. In figure 4 we present an example of the pictures obtained.

![Picture of a retina, seen through a direct ophthalmoscope.](image)

2.5. Retinoscopy
The most commonly used objective refraction instrument in clinical practice is the retinoscope. Before subjective refraction, optometrists usually performed retinoscopy to determine patient’s refractive status. A retinoscope is a small, handheld device that emits visible white light toward the pupil of the eye being analyzed and allows the operator to view the red reflex of light reflected back through the pupil from the ocular fundus [1]. Depending on the kind of movement of the backreflected light (or shadow) an experienced optometrist can evaluate the kind of refractive error present in the examined eye. In order to explain this test, we adapted the webcam to a retinoscope and recorded the shadows in the pupil. Our students could understand how the shadows change their movement during the performance of this test.

2.6 Contact lens fitting
Contact lens practice requires the uses of a slit-lamp in order to evaluate the fitting. Quantification of contact lens movement and the technique of push up cannot be understood without a correct visualization of it. In this context slit lamps with associated cameras are very helpful, they allow teachers to observe and control if the students contact lens fitting evaluation on real time. The webcams adapted to slit-lamps described before also were used to take pictures of lenses in the eye and record lens movement or fluorogram [3, 6]. Moreover, it was used to record the insertion of the lens in the eye or the removal proceeding. In figure 5 we present an example of a picture of a fluorogram used to evaluate rigid contact lens fitting.
3. Discussion

Our experience has shown that webcams are a helpful tool in Optometry lab training. They have several uses and more potential application in teaching task.

In subjective refraction the examiner determines the patient’s refractive error based on the subjective perception of different visual targets. That situation is a problem because the ability to discriminate between dioptric presentations varies among individuals. With the aid of the webcam we can show the stimulus presented to the patient and how it changes with the addition of corrective lenses. It was a helpful tool to simulated refractive errors and present our students how is the vision under a myopia, hyperopia and astigmatism. It was useful in particular in the explanation of Jackson’s cross cylinder which is used to adjust the axis and power of astigmatism [1,2].

There is a bad understanding of colour vision deficiencies, they are called colour blindness and people think that those patients don’t see the colours, but they see them differently. Most of the colours are seen as being more washed out or paler as compared with the way that those with normal colour vision see them. With the aid of webcams and filters we explained this to our alumni. We performed in the pseudoisochromatic charts test but could be used in others colour vision test as Farnsworth’s [2]. It can also help to show how some patients with these deficiencies can be beneficiated from a coloured filter.

Ophthalmoscopy is a simple technique to perform but it is difficult to explain, the webcam recording helps a lot in this task. We can show how the posterior pole is evaluated and what we can see. The ophthalmoscope yields a great amount of magnification and this characteristic makes the field of vision narrower, so the examiner should move the head of the ophthalmoscope with precision to evaluate the patient’s retina. A potential use of the webcam adapted to this instrument could enhance the ability of students in the management and control of the ophthalmoscope.

Retinoscopic findings may be very important in the final prescription of optical correction in some patients as children, low-vision patients, uncooperative patient, or mentally disorder patients. Then, it is essential a good comprehension of this technique by optometrist. At the beginning of the training, the identification of the movement of the shadows is very difficult, so that, webcam recording can help students to realize how they are, they and they move in presence of different ametropies and during the neutralization of the ametropy of the rack lenses used for that purpose.
With the association of webcams in the slit-lamps of our contact lenses laboratory we improve the teaching in the eye health evaluation and contact lens fitting evaluation with this instrument. That is low-cost method in comparison with these devices with associated cameras and showed several advantages. Our alumni revealed a good assessment of our method by means of self-confidence increase and reduction in the training time [5].

4. Conclusions
In general terms, webcams have several advantages in the Optometry teaching. They are inexpensive and could be adapted to a considerable number of optometric instruments for eye health or ocular refraction evaluation. Also they are able to simulate some vision anomalies as ametropies or colour deficiencies and make the student conscious of the vision quality in these patients.

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