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Aplicaciones de la óptica a la medicina
Applications of the optics to the medicine

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Resumen

El trabajo aborda la no percepción objetiva y subjetiva de la importancia de la Óptica para el proceso de enseñanza-aprendizaje de la Física, así como el no aprovechamiento del trabajo metodológico para establecer los nexos interdisciplinarios con la rama de la medicina, se contó con la elaboración de un material docente con aplicaciones de la Óptica, específicamente la oftalmología, donde fueron aplicados varios instrumentos como, encuesta, guías de observación y revisión documental, que permite al estudiante ampliar su formación, la integración de los conocimientos adquiridos, así como la motivación e interés por el estudio de la Óptica.

Palabras clave: Miopía; Hipermetropía; Astigmatismo, Anisometropía.

Abstract

The research addresses the objective and subjective non-perception of the importance of Optics for the teaching-learning process of Physics, thus not taking advantage of the methodological work to establish interdisciplinary links with the branch of medicine, we had the development of a teaching material with applications of Optics, specifically ophthalmology, where several instruments were applied, such as a survey, observation guides and documentary review, which allows students to broaden their training, the integration of acquired knowledge, thus motivating them to be interested in the study of optics.

Keywords: Myopia; Hyperopia; Astigmatism, Anisometropia.

Introduction

At present, it is taken into account that the progress of optics has led to the development of scientific laws that have contributed to the emergence and development of different interdisciplinary branches such as: cybernetics, astronautics, biophysics, and physic chemistry, among others, thus as applied sciences in important fields such as aeronautics, electronics, metallurgy, agronomy, education and medicine. Optical principles, laws and theories form the basis of the technology of numerous activities that take place in the world.

The study of optics is linked not only to the purest manifestation of the phenomenon through physical models and the conformation on this basis and the use of mathematical tools of wave and corpuscular theories, but also to its practical result, which is the explanation of how optical phenomena occur in nature, both living and non-living, and its ability to inform the past and the present. That is why important and representative forms of knowledge of optical phenomena are introduced for the welfare or detriment of mankind, and their contribution to scientific and technical development in general.

The incidence that optical phenomena have on living beings is also considered, both in their spontaneous form and when interacting with the facilities and technical equipment in a utilitarian way to avoid or attenuate harmful actions or affectations to their health, in this sense it is treated with special interest because it is defined as one of the global problems of humanity.

In correspondence with the above, a diagnosis was made on the current state of the work of the subject Optics in the Bachelor's Degree in Education, in the specialty of Physics at Guantanamo University, where several instruments were applied as interview, survey, observation guides and documentary review, which showed as irregularities, the objective and subjective non-perception of the importance of Optics for the teaching-learning process of Physics, thus as the non-use of the methodological work to establish interdisciplinary links with the branch of medicine.

Hence, it is proposed as an objective the elaboration of a teaching material with applications of Optics in medicine, specifically in ophthalmology for the Physics student of the University of Guantanamo.

As a consequence of what has been said above, to implement interdisciplinarity in any field of knowledge is a task that is not without its difficulties. The question lies in being able to carry it out in practice, taking into account that the interdisciplinary work carried out by a group of scientists is not the same as that carried out by a group of pedagogues.

For this, in the development of the teaching-learning process, social, cultural, ecological, economic and other concerns must be integrated, based on the potential of the contents of Optics, which will make it possible to achieve in them a general perception of the world situation, thus understanding the complexity and interactions between global and local problems, their causes and possible solutions.

From these conceptualizations, a marked intention to associate interdisciplinary relationships in terms of knowledge, skill systems, system of values and convictions in relation to the world around us is evident.

The early 18th century saw the emergence of extremely important studies in the study of Optometry:

- Benjamin Franklin invented the bifocal lens, which made it possible to see more accurately both far and near through the same lens.
- John Dalton described color blindness, a visual defect related to color perception.
- Thomas Young conducted studies on physiological optics, to explain how the eye adjusts its focus at different distances thanks to the curvature of the crystalline lens. This eventually helped to recognize the so-called astigmatism.

From these events, in the following centuries different types of testing lenses were developed and the first ophthalmoscope was invented, which made it possible to see inside the eye.

Yes, the history of Optometry is full of events. Important mathematicians, physicists and research professionals have participated throughout time to study eyesight and the diagnosis and corrective treatments for its problems, hence the importance of this work in the Physics career.

Development

The subject Optics, addresses the discoveries and essential laws that in the historical development of physics have made it one of its transcendent branches for the understanding by man of the world around him and for its transformation for the benefit or detriment of Nature and society, in line with the importance of these contents for the formation of the future professional of education of the Physics career with the E Curriculum, achieving its contribution to the development of creativity in future graduates, entering the world of health with a technical vocabulary that allows them to identify the physical laws, This is achieved, not only through the contents, but also by the methodology with which the teaching-learning process is developed through lectures, practical classes, seminars, laboratory practices and other forms of teaching that are considered appropriate, since the topics developed require the integration of acquired knowledge, individual analysis and collective discussion of new situations, such as real life problems that have no exact or unique solution, the use of assisted research.

In correspondence with the object and development of Optics, the content of the course covers the characterization of the nature of light following the historical evolution of the discoveries related to elements of the wave theory, the electromagnetic spectrum, its speed, the refractive index, dispersion, the optical path, Fermat's Principle, the laws of reflection and refraction, the total internal reflection, the optical fiber, the prism, the emission, absorption and diffusion of light and the elements of geometrical optics.

On the basis of the wave model, the phenomena of interference, diffraction and polarization are explained. Finally, using Einstein's quantum model, the interaction of light with substance is explained for high frequencies, with particular emphasis on black body radiation and the photoelectric effect. In the fulfillment of this task, he studies the interactions between light and substance and their effects, arriving at the establishment of laws and principles of this content, for which he uses mainly the conservative method.

The following reasons, among others, justify the existence of the subject:

- Its contribution to the formation in the student, of a scientific conception based on dialectical materialism, by developing a set of convictions that determine to a large extent their behavior before the problems that life itself poses to them.
- Its place and importance within the study plan allows consolidating the pedagogical professional vocational training of students, at the same time that it can contribute through the treatment of its content to provide the future teacher with tools for the vocational orientation of students of basic secondary, pre-university, technological and adult education.
- Its contribution with the curricular strategies making correct use of the mother tongue and the use of the English language, thus as the relationship Science Technology Society and Environment and the understanding of the increasing use of optics in other branches of the scientific-technical work, the appearance and development of special areas and the own methods of investigation, which has extraordinarily increased its role for the man at the present time.

- Its content covers the optical phenomena that occur in the micro world, the macro world and the mega world, that is, from the nuclear scale of the order of 10-15 m to the great distances of the order of 1025 m existing up to the most distant galaxies observable at present, of vital importance for the formation of a future Physics teacher.
- Its logical-methodological function in the preparation of the student for the execution of scientific activity, propitiated the evolution and structuring of the wave and corpuscular theories of light, the role of experiment and the work of physicists in each epoch, through the application of a series of procedures and categories of the research activity, which show students the way in which scientific knowledge is achieved.

On the other hand, the course should promote a new learning culture that allows overcoming traditional styles, using methods and procedures that dynamize the learning process and enhance cognitive development, with emphasis on thinking and intelligence, thus motivation and interest in the study of Optics. To this end, the subject should promote autonomous and self-regulated learning of the student, which contributes to build their own knowledge and develop meta-cognitive potentialities and transferable skills for continuous learning throughout life, so that it can be inserted effectively in today's society.

The dioptric power of the eye is fundamentally determined by:

- The cornea and the crystalline lens: they act as converging lenses, since when passing through them; the rays converge to focus on the retina.
- The axial length: this is the anterior-posterior distance of the eye, which will require a greater or lesser need for convergence of the rays depending on whether the eye is shorter (hyperopic) or longer (myopic).

The dioptric power of the cornea is constant, while that of the crystalline lens can increase (and considerably in children) thanks to the effort of accommodation, which allows us to focus on both distant and near objects.

In the eye

When the shape or size of the eye is not adequate, there will be graduation defects, which are corrected thanks to the use of different types of lenses. Thus, in a simplified way we can say that if the size is large, we will talk about myopia, while if it is small it will be hyperopia. When the eye is not rounded, we will speak of astigmatism and presbyopia when it does not focus well.

Optometrists and ophthalmologists usually prescribe lenses graduated in diopters. The power of a lens, in diopters, is equal to the inverse of the focal length in meters, that is, P=1/f.

Refractive, refractive, optical or ametropic defects occur when the eye, in a relaxed state, is not able to focus the parallel rays coming from the theoretical infinity on the retina, causing poor vision, as an unsharp image reaches the brain. They are: hyperopia, myopia and astigmatism, and they are the most frequent cause of bad vision.

The oldest method for correcting vision problems caused by refractive errors is prescription glasses or corrective eyeglasses. There are three types of refractive errors: nearsightedness, farsightedness and astigmatism.

The three refractive anomalies

Myopia is a refractive problem that causes the sufferer to perceive distant objects without sufficient sharpness. The reason is that the image is formed in front of the retina and not directly on it, which would be optimal for good vision from any distance, for one of these two reasons or a combination of both.

The eye is more elongated than normal.

The cornea and/or lens is over-powered. Hyperopia, on the other hand, affects near vision (although at certain ages it also causes blurred vision at long distances) because the image is focused behind the retina, i.e., just the opposite of what happens in myopia. The cause of this defect may be due to inadequate corneal or crystalline lens power, or to the eye being shorter than the parameters considered normal.

Finally, astigmatism (which often occurs together with one of the two previous defects) is caused by an irregular corneal curvature. The effect is poor vision at all distances.

How do spectacles correct these defects?

Prescription lenses have long been used to correct visual defects caused by anatomical features of the eye. These make it impossible for the luminous image entering the eye through the pupil to form exactly on the retina.

The form of correction varies according to the refractive defect in question:

Myopia: This is a refractive defect whereby parallel rays incident on the eye will focus in front of the retina. The rays that enter diverging will form a focus closer to the retina. For this reason, the subject will see objects located at a certain distance or more poorly, but there will always be a point close to the retina where his vision will be correct.

Optical Correction

For cases of myopia, a concave lens is used to change the direction of light so that the image is formed right on the retina. This improves the distance vision of myopic people. The image that normally forms before the retina must be brought to the retina. A lens that produces this effect must be placed in front of the eye. And this is done by a diverging lens, whose main physical characteristic is that it is thicker at the edges than in the center, which is why the smaller the frame chosen, and the rounder it is, without peaks, the thinner the lenses will be.

The treatment of myopia is based on the correction of the defect with glasses or contact lenses. One of the most debated issues is the way in which this correction is carried out, especially in children. The prescription of full correction is based on improving vision to the maximum and developing a normal accommodation-convergence relationship. This will allow for better educational and mental development. The use of bifocals to relax accommodation has not proven to be effective, although it continues to have supporters. The opposite theory is even advocated, i.e., hypercorrecting the myopic subject to better control its progression.

Hyperopia: An eye is farsighted when it is too short for the curvature of the cornea, or when the cornea is too flat or "flat" for a certain length of the eyeball. In these patients, the light rays are focused behind the retina, because the eye does not have enough power to modify their direction and, as a consequence, the image is blurred. It is important to note that a farsighted person can, however, focus the image on the retina thanks to an intraocular muscle, the ciliary muscle. This muscle makes it possible to modify the curvature of the crystalline lens, thus compensating for the hyperopic eye's inability to correctly modify the path of the light rays and focus them on the retina. With the passage of time, the ability to focus, thanks to this muscle, is gradually lost.

Young people with severe hyperopia lose clear near vision, although they maintain good focus on distant objects, thanks to the accommodative power of the ciliary muscle. However, those over 40 to 45 years of age with hyperopia that is not necessarily very high, due to muscle fatigue, have little accommodative remnant. Therefore, their distance vision is defective. Thus, in addition to the difficulty in near vision, distant vision is blurred, due to the fatigue of an overtaxed ciliary muscle that is unable to fully compensate for the refractive error. In other words, in hyperopic patients with presbyopia, there is a combination of blurred near and far vision, due to muscle fatigue of an organ that was "overused" during youth to compensate for a "hidden" hyperopia.

Hyperopia (farsightedness) is a form of refractive error in which the rays incident on the eye focus behind the retina. It is a very common defect, but mostly reaches a few diopters; unlike myopia, it is not a progressive defect and lacks such serious complications. In the case of hyperopia, on the other hand, a convex lens is used so that the image is formed on the retina and not behind it, thus improving near vision in people with this refractive error. The convex lens is also used for people with presbyopia.

Astigmatism: According to different criteria, the types of astigmatism can be classified according to the following:

- The point at which the image is focused:

Pure astigmatism: one of the meridians focuses on the retina and the other, depending on the curvature, can focus in front of the retina (myopic astigmatism) or behind the retina (hypermetropic astigmatism).

Mixed astigmatism: one axis focuses in front of the retina and the other behind.

- Its causes:

Regular astigmatism: it is usually congenital and not chronic. It is due to the formation of two axes in the eye that refract light with different intensity, because the curvature of the cornea is very modified, depending on the refraction of light in the meridians, we can distinguish the following types of regular astigmatism:

Frequent astigmatism: light is refracted more intensely in the vertical meridian.

Rare astigmatism: light is refracted more in the horizontal axis.

Irregular astigmatism: it is due to a change in the curvature of the cornea due to injuries, surgical interventions, etc. In this case, two irregular axes are formed that refract light with a very varied intensity and direction.

Temporary astigmatism: due to a surgical intervention, the corneal layer may be retracted, which causes changes in light refraction that are usually temporary and can be fixed spontaneously.

Astigmatism correction.

Astigmatism can be corrected by means of theoretical corrective lenses or contact lenses. In both cases, the thickness of the lens will be greater in the center. The thicker the astigmatism, the stronger the astigmatism will be.

It is an entity in which the light rays do not form a focus, because the optical system does not have the same refractive capacity in all meridians. The optical phenomenon has been explained by means of Sturm's conoid; practically all people present some degree of astigmatism, but the concept refers to those situations in which the defect becomes significant.

Astigmatism, which often occurs in conjunction with either of the above two defects, occurs because the cornea has an irregularity in curvature. The effect is poor vision at all distances.

Anisometropia: consists of a difference in the refractive error of the two eyes. The combinations present a great number of possibilities, both in type of defect and amount. It is often a congenital problem, but it is not always detected early.

Anisometropia is important because it is a predisposing factor for amblyopia and strabismus. It also poses peculiar problems in optical correction. The limits of anisometropia cannot be defined. It has been suggested that two diopters of difference between both eyes would be the limit, but this is not satisfactory, as symptoms and inconveniences may appear more or less frequently. Other factors that will influence are: fusion ability, previous optical corrections, and types of defect, age and refractive changes.

Treatment

Prevention of amblyopia is the first problem to be solved in an anisometropic patient. Classical measures such as occlusion and the use of the appropriate correction are especially important in cases of anisometropia. Due to the different prescription in each eye, the size of the images is not homogeneous, which is called aniseikonia. This causes symptoms ranging from asthenopia to diplopia or blurred vision. To reduce this phenomenon, the design of spectacles requires special considerations:

- Maximum proximity of the most powerful lens to the eye.
- Maximum distance from the less powerful lens to the eye.
- Minimum curvature on the anterior face of the more positive (or less negative) lens.

Astigmatism is corrected with lenses that counteract the irregular shape of the corneal curvature.

Presbyopia

The eye has a natural lens, the crystalline lens, which automatically focuses the eye at any distance. From 35 to 45 years of age, the automatism begins to fail and the near focus becomes difficult. The name presbyopia or eyestrain refers to a decrease in the eye's ability to accommodate in order to form a sharp retinal image of objects located at a near distance.

The cause of presbyopia lies in the physiological decrease in the ability of the crystalline lens to adopt a spherical shape and adapt to the vision of near objects. The great adaptability, the ability to see correctly at different distances, is remarkable in young individuals. It is 14 diopters at 5 years of age, decreasing to 7.5 at 35 years of age. At 45 years of age there are still 4.5 diopters and at 50 years of age only 2. At 60 years of age the result is close to 0.

Some people over 50 can read without glasses, usually because they have some degree of myopia or myopic astigmatism, or because they are developing a cataract that alters the shape of the crystalline lens, which paradoxically allows them to see up close without glasses.

The tired eyesight leads to the inability of the eye to fixate a near point. One of the first signs of eyestrain is blurred vision at close distances, requiring objects (cell phone, newspaper, etc.) to be moved farther away in order to see them clearly. Presbyopia can cause headaches when looking at a book or computer screen for a long time. The near focusing error increases progressively until the age of 60 when it stabilizes at a plateau. Until then, every two or three years, the near prescription must be adjusted for correct focusing.

15 Treatments

Presbyopia cannot be cured, although there are different methods to compensate for the loss of accommodation or focusing ability of the crystalline lens.

Presbyopia is usually corrected with glasses.

There are three types of glasses depending on the needs of each patient:

- Bifocal: prescription to correct distance and near vision.
- Trifocal: focus on distance, middle distance and near vision.
- Progressive: the upper part of the lens is used for distance vision, the lower part for near vision, and the central part has a progressive graduation covering all distances. In addition to glasses, you can also use monofocal contact lenses, which use two different lenses, the one in one eye is adapted to focus on near vision and the one in the other eye is used to focus on distance, achieving, after a period of adaptation, to see at both distances.

Currently, among the techniques that preserve the crystalline lens, surgical correction with excimer laser using a new aberration optimization system is the treatment with the best results.

To determine the appropriate treatment or surgery, it is important to perform a personalized study of the patient to detect other key factors such as age, profession or personal preferences. Whether we use glasses or contact lenses, as if we perform a laser treatment for presbyopia, we get a temporary solution for vision loss or eyestrain, being necessary to compensate with a new prescription of glasses after a while.

Permanent treatments for presbyopia are based on the replacement of the eye's natural lens (crystalline lens) with a multifocal intraocular lens. These processes are known as Multifocal

Intraocular Surgery.

Under normal conditions, it is sufficient that accommodation allows focusing on objects between infinity and the reading distance. This means that when the amplitude of accommodation decreases there may be difficulties in near vision. This situation is normal from the age of 45 years and progresses until approximately 55 to 60 years of age. Under normal conditions, it is sufficient that accommodation allows focusing on objects between infinity and the reading distance. This means that when the range of accommodation decreases, there may be difficulties in near vision. This situation is normal from the age of 45 years and progresses until approximately 55 to 60 years of age.

The symptoms of presbyopia are very typical:

- Moving away from the reading plane.
- Difficulty in near work.
- Delayed refocusing at distance after continued use of accommodation.
- The above symptoms are accentuated in low light and at the end of the day. Elderly patients may have improved near vision as a result of myopia induced by lens sclerosis and senile myosis.

Presbyopia correction is performed with convex lenses to compensate for the lack of accommodation. To do so, it is necessary to previously determine the defect in distance vision and take into consideration the age and occupations of the subject, automatically the diameter of the pupil to regulate the luminous intensity received by the eye.

Conclusions

The proposed teaching material is feasible and valuable from its implementation, it is coherent and logical achieving significant changes in the different ways of acting of the students, it constitutes an instrument for teachers to observe with another look the establishment of interdisciplinary links with the branch of medicine, specifically ophthalmology, where the conception of the content favors a vision of science that allows it to be perceived as a process in continuous construction, hence the need to present the laws and theories that explain the optical phenomena as a continuous process of search and as the result of the knowledge of the physical world.

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