Art analysis, the Photoelectric Effect and the Electromagnetic spectrum in a Physics class

Brenda SAAVEDRA (1) (2), César MORA (1), Mirna VILLAVIENCIO (2)

(1) CICATA, Unidad Legaria del Instituto Politécnico Nacional, México
(2) UNAM, Departamento de Física, Facultad de Ciencias, Ciudad de México, México.

Abstract. This work presents a didactic strategy for High School students, integrating Physics concepts like the electromagnetic spectrum and the photoelectric effect to analyze artworks. Students investigate noninvasive spectroscopic techniques to examine pigment composition and artwork history. Then the students create infographics to communicate their findings, use ultraviolet lamps to reveal hidden details in currency bills, demonstrating the electromagnetic spectrum's applications. Finally, they analyze artworks by Remedios Varo, discussing the properties of electromagnetic waves. These activities foster critical thinking and practical scientific inquiry, enhancing appreciation of both science and art preservation.

Introduction

In recent years, the necessity of interdisciplinary work to solve many problems has been evident, contrary to rookie physics students' idea that physics is a natural science independent of other areas of knowledge. Notably, it is usual to think that physics and art have no relation. Nowadays, the intersection of physics and art history has transformed significantly and demonstrated its practicality. Numerous techniques derived from applied physics are now used to study and create art, providing tangible benefits. For example, radiocarbon dating methods are employed to determine the age of archaeological artifacts, and ionizing radiation is used to preserve precious objects. Among these applications, non-invasive methods have emerged as particularly promising avenues for art analysis.

The integration of physics and chemistry has become increasingly pivotal in preserving our historical and artistic heritage, as Durán [2] has noted. These disciplines are not just academic pursuits, but they also play a crucial role in ensuring the authenticity of artworks, deciphering the origins of raw materials, and uncovering the intricacies of manufacturing techniques.

This dynamic relationship between physics and art fosters a deeper understanding of both disciplines and promotes the synthesis of interdisciplinary knowledge, as underscored by Álvarez [1]. By intertwining scientific and artistic elements, scholars can unravel complex problems and generate integrated insights that transcend traditional disciplinary boundaries.

Ruiz [4] advocates for adopting project-based learning (PBL) methodologies in educational settings, emphasizing their efficacy in empowering students with profound knowledge.

Furthermore, it is imperative to address the prevailing challenges in science education and highlight the relevance of physics in everyday life, as emphasized by recent literature [3].

Theoretical framework

The integration of physics in art analysis is rooted in the interdisciplinary nature of these fields. Applying principles of physics and chemistry, researchers have entered the mechanisms governing artwork creation, preservation, and analysis. This framework encompasses diverse subfields, such as spectroscopy, radiography, and material science, which provide unique insights into artworks' composition, structure, and historical context.

Of the above arises the question of the possibilities of using art in physics teaching. These inquiries often revolve around the effective utilization of non-invasive spectroscopic techniques to analyze artworks without causing damage, the limitations and challenges associated with using physics-based methods for authentication and dating of artworks, the role of technological advancements in refining art analysis techniques, and the significance of interdisciplinary collaboration in advancing our understanding of the relationship between physics and art.

An original aspect of this research lies in its interdisciplinary approach, bridging the sciences and humanities to enrich our understanding of cultural heritage. By leveraging physics principles in analyzing artworks, scholars uncover new perspectives and insights that contribute to our collective knowledge. Developing innovative techniques and methodologies tailored to the specific needs of art analysis represents another original aspect of this research endeavor. This includes adapting existing physics-based methods and exploring novel approaches to address emerging challenges in the field.

Methods and findings

This work presents a didactic strategy in which High School students explore how Physics concepts, such as the electromagnetic spectrum and the photoelectric effect, can be applied to analyze artworks.

The implementation takes place at Logos, a High School located in Mexico City, in the Physics III course for fourth-year students. It involves two heterogeneous groups of 25 students each, aged 15 to 17.

As a first activity, the students will develop their inquiry abilities by investigating, using different kinds of references, how noninvasive spectroscopic techniques, such as X-ray fluorescence and infrared spectroscopy, are used to examine artworks without damage in order to discover the composition of pigments and materials used in them, gaining insights into their creation and history. To communicate their discoveries, the students must elaborate on an infographic using their creativity to construct their artwork.

As a second activity, we propose collaborative work using ultraviolet lamps, which can be obtained in electronic supply stores, to discover invisible details in bills. This is a clear example of how the electromagnetic spectrum can be used to discover invisible marks. This activity is used to discuss the use of light of different frequencies to reveal details in art.

Finally, there are pictures of Remedios Varo and other pictures where the behavior of electromagnetic waves can be observed. The students have to discuss among the group whether the properties observed are correct.

Despite encountering challenges, students will develop critical thinking skills in these activities and gain practical scientific inquiry experience.

Conclusion

This didactic strategy has illustrated how physics concepts can enhance our comprehension of art and facilitate interdisciplinary education. By investigating techniques such as X-ray fluorescence and infrared spectroscopy, we have grasped intricate physics principles and witnessed their practical application in art analysis without causing harm.

This implementation, through its challenges, has not only reinforced our understanding of physics concepts and their practical significance but also spurred critical thinking and creativity. It underscores the importance of collaboration across disciplines, fostering connections between seemingly disparate fields and enriching our educational experience.

References

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