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Let's Talk About Stereochemistry for a Moment: A Home Experiment Conducted with College Students in Social Isolation

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Due to COVID-19, we are adjusting to a new educational environment while also being socially isolated. By combining previously established ways of remote education with video conferences, the world is creating a new sector termed techno-pedagogy. The concept of stereochemistry in Organic Chemistry is frequently difficult to understand even in classroom teaching. Plane-polarized light rotation is difficult to describe because it needs a high level of abstraction in the mental exercise. As a result, we propose in this work that technology be developed to teach stereochemistry remotely. As a result, we prepared a training video that shows college students how to execute a hand-made stereochemistry experiment. Lecturers, undergraduates, and graduate students all gave the video great scores.

Graphical abstract

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1. Introduction

We have experienced a pandemic condition in the previous two years, in which our way of life has changed day by day and we must adjust to a new scenario using the instruments supplied by modern technologies [1]. Previously, during the third industrial revolution [1, 2], a new industrial revolution began to obscure the relationship between the physical, biological, and virtual. Because of the possibility of contamination by the novel coronavirus, schools, universities, and educational institutions are now dangerous locations (COVID-19). Due to the necessity of preserving social distance to prevent new COVID-19 mortality, efficient instructional approaches based on Industry 4.0 technologies are required.

Stereochemistry is a branch of organic chemistry that is important for understanding biological topics like molecular

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recognition, DNA, and smell; in chemistry, students should understand asymmetric catalysis and other asymmetric molecular phenomena [3]; in bioengineering, engineers should understand the bioprocess and thus increase the production of biofuels like ethanol, for example. Furthermore, understanding stereochemistry enables the identification of purity in the sugar sector, as example, which is a crucial factor demanded by consumers all over the world. The rotation of plane-polarized light, for example, is a physical constant that may be utilized as a purity reference for various chiral substances [3, 4].

To teach stereochemistry under normal circumstances, it is necessary to have a basic understanding of chemical structure, relative and absolute configuration, and, last but not least, three-dimensional representation over a two-dimensional paper sheet. Students can learn these skills in a regular classroom with teacher assistance and a pedagogic tool to visualize the tridimensional item, such as the molecular model [4]. Because basic concepts are not easy to understand that's why exercises and simulations are essential. Even with this teaching structure and all of these instruments, starting students find stereochemistry difficult to comprehend [5].

For an organic chemist, the capacity to see molecules in three dimensions is crucial. The second set of skills demanded of an organic chemistry student is the ability to label molecules as *R* or *S* using CIP (Cahn-Ingold-Prelog) rules to indicate an absolute configuration [4]. Since 1960, various teaching approaches for stereochemistry have been developed to improve student comprehension. Hands were commonly used as asymmetric teaching tools to label molecules as *S* or *R* in the beginning [4]. We are currently updating our teaching methods, and we are now using plastic molecular models as well as computer software to demonstrate molecules in three-dimensional detail [5].

Physical features of chiral molecules are difficult to describe in practical classes [3-5]. The fundamental experiment to demonstrate the practical face of the chiral molecule is the measurement of rotation of plane-polarized light using a polarimeter. We have limited financial resources in Brazil to conduct these practical stereochemistry classes. Chiral chromatography, polarimetry, and other techniques for evaluating chiral compounds are not available in undergraduate chemistry classrooms. To overcome these challenges, new didactic classes based on low-cost resources and do-it-yourself techniques must be proposed [3].

The generating issue is Paulo Freire`s educational methodology which stands for education based on social needs from a specific studying object [6]. According to Freire`s methodology, the knowledge is learned from the student when the study object is contextualized in the social environment where it is involved. [6] Social disconnection was a result of social isolation required by pandemia affecting a lot of important aspects of traditional education. To overcome this situation is important to develop educational tools to be made at home, thereby involving a student in the process to build and learn academic and college topics by themselves. Freire's educational methodology should be adapted to a pandemia scenario considering its educational worth [6, 7]

The global epidemic brought on by COVID-19 put an end to our old way of life, forcing us to adapt to a new and different situation. We need to employ technologies available in a world where industry 4.0 and the Internet of Things (IoT) are present to keep teaching some topics like stereochemistry and polarimetry, which were difficult to teach before the epidemic. Remotes Classes, virtual seminars, and forums linked to educational institutions are now required to assist students in continuing to study [1]. This project has two goals: the first is to create a training video using a free edition video application, and the second is to teach college students how to conduct a homemade experiment on the rotation of plane-polarized light.

2. Material and Methods

Following global educational proposals to continue learning while ceasing physical attendance at school, we consider what has previously been done to improve distance education for children and adults [2]. The answer is synchronous and asynchronous lessons created by various moviemaker programs, as well as educational apps like Feed the Monster®, which helps kids learn, recognize letters, and construct some fundamental words [8]. There are two parts to our process. The first is to carry out the handcrafted experiment described in the video, and the second is to use a moviemaker program to create a short film.

The rotation of plane-polarized light was performed using common household chemicals and items. To begin, we used a polarizer from a watch or a calculator, sugar, a cell phone as a light source, a computer screen as a source of polarized light, a rubber band, two glasses, and water. We were able to conduct experiments similar to those conducted with a polarimeter using these materials. When the solution contains sugar, we saw a difference in the light that passed through the glass of water. To gain the fullest understanding of the issue, the student must, of course, be guided remotely by a supervisor.

The second section is about the present plan to educate from afar due to social isolation. To create the short film, a free movie creator tool named ApowerEdit® was utilized. This short film was created as part of a stereochemistry class at the Universidade Federal do Rio de Janeiro (UFRJ/Brazil). This film is part of a small library of films created by academics at this university as part of a new approach to creating asynchronous material for students to see. This is a new trend around the globe; it's called techno-pedagogy, and it's a new tendency toward a new world paradigm. To confirm our work as a simple and effective techno-pedagogic tool, we tested it on a small group of eight students and three organic chemistry professors. The two criteria we looked at in our research were how easy it was to understand the explanatidcon and how easy it was to experiment.

The students were given access to the film via YouTube® and we've posted this movie on the university's Virtual Learning Environment (VLE). The video found at **https://www.youtube.com/watch?v=ZV_bcD1hh7k** makes the experiment simple to follow. All of the pictures used to make the video are licensed under a Creative Commons license (CC).

3. Results and Discussion

To understand the unseen and intangible quantum world, Chemistry has always been taught via approximation in the world we live in [3-5]. It has been utilized as a techno-pedagogical tool for movies, apps, animation, and other unconventional didactics material to avoid misunderstanding and misinterpretation [8]. The instructor's function is preserved in techno-pedagogy since it is critical to aid students in comprehending topics today and in the future.

Video-conferencing has been used as a method to connect students and professors for a long time, and the number of articles in this field is enormous and expanding [9,10]. Desktop video-conferencing (DVC), Interactive Video-Conferencing (IVC), and Web video-conferencing (WVC) are the three types of video-conferencing now available for remote teaching [10]. WVC, on the other hand, is less expensive, has a better relationship with students, and has produced the best results following lessons. WVC has been subjected to a constructivism and cognitivism analysis to find educational paradigms distantly and to utilise them following social isolation produced by COVID-19 [10]. WVC helps students to experience a different style of learning and increase their comprehension of a topic by using constructivism analysis. This is a crucial pedagogical truth to avoid misunderstandings while teaching a difficult topic by analogy [10]. In contrast, according to cognitivism theory, students develop the ability to dialogue with a chemistry issue and so find a way to handle challenges with ambiguity in knowledge [10].

This experiment matches to issue generating idea from Paulo Freire's educational methodology to teach science or another thematic to students. [6] Using ordinary material easily to be afforded to anyone in social isolation this experiment presents a solution to be used at home or in a classroom where a plane-polarized rotation experiment is not easy to be performed. On one hand, we have a student building his educational material and in another hand performing his experiment. [6, 7] This tutorial surrogates a traditional classroom and goes forward when putting the student as the central figure to build his knowledge.

Some stereochemistry experiments are difficult to visualize because they are too abstract, even though great drawings and representations may be found in the literature. We created a film exhibiting the rotation of plane-polarized light using inexpensive materials to illustrate the topic of physical properties from solutions containing chiral compounds. WVC is a video streaming approach that is recorded and made available to students during stereochemistry sessions. This short film about stereochemistry was created to be viewed asynchronously, on a cell phone or other device as many times as the students needed.

It is critical to determine qualities from a solution containing a chiral molecule in the chemical laboratory during an experimental lesson on stereochemistry. The idea of specific rotation is described in stereochemistry, and it allows for the measurement of the rotation of plane-polarized light in a solution containing a chiral chemical in standard conditions, as well as comparisons to reference literature [3-5]. Specific rotation is a quotient between observed plane-polarized light over the product between concentration (g/mL) and path length of the cell where the light goes through (dm) (Equation 1). A temperature adjustment and a specification of the wavelength of the light employed are required for an accurate rotation measurement. A polarimeter, analogic or digital, is required to determine the particular rotation at class, although the deviation of plane-polarized light is the most important to visualize.

$$[\alpha] = \alpha \,.\, [(C) \times l]^{-1} \qquad (1)$$

A qualitative experiment is proposed to determine the influence of a chiral chemical in solution. We started our experiment using sugar, a chiral molecule, and water, a universal solvent. This experiment can be carried out by anyone who has access to sugar and water. The polarizer is made from an old calculator, and the source of the polarized light is a regular laptop's screen. When we moved the polarizer over the laptop screen after preparing the water-sugar solution, we saw a qualitative shift in the light's behaviour. When we made the same movement over the cup of glass containing simply water, there are no changes in polarized light. We emphasize that all of the items used in the experiment are safe for students, inexpensive, and easily accessible.

Given the use of WVC in remote classes and the lack of a lab experiment, this video is a viable choice for discussing plane-polarized light rotation and stereochemistry. According to the World Economic Forum, when the correct techno-pedagogical technique is used, e-learning is expected to produce better results in terms of information retention and learning time [9]. The integration of new technology into information allows students to learn at their own pace while simultaneously motivating them to learn systematically. [13]. Short movies that can be replicated everywhere and are repeatable are critical in a new industry and world environment [11,12]. As a result, our study corresponds to new techno-pedagogical methodologies as well as a new global scenario [11-14].

Our conclusions are based on qualitative comments from our small group. Following the viewing of the film, questions about the issue discussed in the video were posted. The video was then graded as either understandable, not understandable, or in need of remaking. All participants unanimously chose the highest possible score for our short film to be utilized as the WVC. Despite the lower number of participants, it is statistically significant. We intend to use our short films in a variety of classrooms, taught by a variety of teachers, and for a variety of chemical courses shortly. Soon, we hope to create a shorter film like this on several chemistry topics to aid in our new scenario during the isolation social and afterwards.

4. Conclusions

We achieved our goals since we created a short film and proposed a low-cost experiment that could be done safely and is also valuable from a techno-pedagogical standpoint. Furthermore, we designed this WVC product using constructivism and cognitivism philosophy, allowing students and teachers to consume information asynchronously. We hope to apply the same methods shortly, grow the number of chemistry topics covered, and reach a larger number of students and instructors.

Supporting Information

Link to youtube® vídeo:
https://www.youtube.com/watch?v=ZV_bcD1hh7k

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Author Contributions

PMM performed conceptualization, investigation, methodology, resources, software, writing – original draft and writing – review & editing. JCB and TLS performed conceptualization, investigation, supervision, writing – original draft and writing – review & editing.

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