Interpretation and use of the image in high school physics courses

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Abstract

In the context of the scientific technological society, the transmission of information through visual media takes central importance. However, the use of images, far from being trivial or direct, requires that people reflect, review and analyze the information so that it is transformed into knowledge. The use of an external image as a way to help students to build mental representations is currently a main area of study in science education. The research we are doing is to use the image as a teaching strategy to assist the development of visual literacy in physics. Such research is outlined in three phases: exploration, implementation and evaluation, and will be carried out in real high school classroom. The results obtained in the course of the exploration stage indicate that, in activities focused on the reading of an external image, students produced alternative interpretations, not only omitting information present in the image, but reformulating and even adding information which is not deductible from the explicit context. We believe that these results work first as a diagnostic evaluation to learn some aspects of mental representations of the students and second to allow the teacher implement strategies for pupils so that they develop mental representations which are closer to those accepted by science. This paper presents the results of the exploration phase in the themes of waves and electromagnetism.

Keywords: Image interpretation, visual representation, methods in physics education.

Resumen

En el contexto de la sociedad tecno científica, la información a través de medios visuales toma una importancia crucial. No obstante, lejos de ser el uso de la imagen trivial o directa, requiere de mecanismos que permitan al individuo participar de manera activa, eficaz y crítica para que dicha información se transforme en conocimiento. La utilización de imágenes externas como una forma de ayudar a los estudiantes a construir representaciones mentales es actualmente una de las líneas de investigación en didáctica de las ciencias. La investigación que estamos realizando, tiene como objetivo crear algunas estrategias didácticas basadas en el uso de la imagen, que permitan coadyuvar al desarrollo de la alfabetización visual en física. Dicha investigación está planteada en tres fases: exploración, implementación y evaluación. Los resultados obtenidos durante la primera etapa indican que, al plantearse actividades cuyo centro es la lectura de imágenes externas, se presentan entre los alumnos interpretaciones alternativas que, entre otras cosas, no solamente omiten información presente en aquellas, sino que reformulan e incluso añaden información no deducible desde el contexto explícito. Pensamos que esas interpretaciones sirven, por un lado, como evaluación diagnóstica que nos permite aprender algo sobre las representaciones mentales de los estudiantes y segundo permite al maestro implementar estrategias para los alumnos de manera que puedan desarrollar representaciones mentales que sean más cercanas a las aceptadas por las ciencias. Este trabajo presenta los resultados de la fase exploratoria en las áreas de ondas y electromagnetismo.

Palabras clave: Interpretación de imágenes, representación visual, métodos en didáctica de la física.

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I. PRESENTATION OF THE PROBLEM AND BACKGROUND

In today's society image is omnipresent and can make us victims of an image that supposedly speaks for itself and requires no further explanation. In this context it is pertinent to ask about the role played by the image in the teaching-learning process and their relation with the skills to be promoted among students of high school.

In general, one of the characteristics of ICTs has been the use of the image as a means of conveying information. Nevertheless the mere transmission of information is not the purpose of the media, but the assimilation of it by the recipients. This means that recipients must be able to retrieve the information, relating text and images to their previous knowledge and ideas; however it is uncertain in what percentage they are able to recover and assimilate that information.

It is needless to conduct a systematic investigation to realize that significant areas of the textbooks of physics at all levels are filled with images. Perales and Jimenez [1] conducted an investigation of the use of illustrations in textbooks and develop taxonomy for classification. They conclude that in the texts analyzed by them the most common use of the image is decorative; so the question on the use of the image to the learning of physics becomes more pressing. Elsewhere the same author [2] concludes that the images should not be considered as mere contemplative objects but that it is needed to work with them intensively: Observing, modifying, criticizing and replacing them in different contexts in order that they may contribute to active learning. Another study [3] points out that to learn meaningful form a text accompanied by illustrations, assumes the existence of a dual processing channel, and the combination of linguistic and visual resources must be done with a clear relationship.

Some researchers point out a low value of the image element to increase meaningful learning of concepts in physics [4] as a result of a comparative study between two groups, one under a traditional teaching and the other subjected to intensive but demonstrative use of images. They state that the visual representation requires certainly a different treatment than the mere display and its usefulness, in that study, apparently focuses on motivation.

On the other hand a study [5] in a population of university students points out some advantages and difficulties in using multiple representations, particularly when considering the relationship between textual and visual representations, concluding: That, most multimedia enabled better identification and construction of relations of higher diversity, accuracy, description, and novelty, than did the textual display and that curriculum designers and teachers should be aware of cases in which rich multimedia constrained performance. Researchers in the field of communication [6] suggest that the increase in media has not brought an increased in media literacy of the media generation.

By contrast, research from the area of psychology [7] seem to support the idea that, although the use of the image is not the solution to educational problems, it can provide valuable input directed toward developing learning skills which practices does not stimulate an encyclopedic learning of disciplinary content.

The image continues to play a secondary role in most physics courses in Mexico. Although images are sometimes used in the courses to illustrate the problematic context (*e.g.* mass and spring system) or as a mechanism of conceptual representation (*e.g.* graphics methods for representing vectors) or for abstract representations of relationships between sets of data (*e.g.* graphics functions), reading and study of the image is not an end in itself, leaving aside its evaluation and development of associated skills.

These results lead to posing the question of research on the use to be given to the images in classroom to ensure that students may read them. We called it "visual literacy in physics "*The set of skills necessary for the individual to participate actively and critically of the visual language and visual communication, common in a techno-scientific society, establishing links between them and the conceptual, procedural and affective dimensions of physics.*

The definition of visual literacy contradict the popular assumption that the images do not require further interpretation, but rather it is assumed that the reader needs another skill to interpret its content. Among the elements of visual literacy in physics, one of the cores is the development of students' ability to read and create images related to physical phenomena. Within the classroom, each student must play the role of interpreter of the images presented by the teacher (at least ideally), and should establish one or more meanings in agreement to the context in which it is presented.

The process of interpretation involves the introduction of a series of cognitive processes that could be interpreted from different theoretical frameworks depending on the activity. These are Ausubel's Theory of Meaningful Learning, Johnson-Laird's Theory of Mental Models or Vergnaud's Conceptual Fields Theory or an integration of them [7]. With these conceptual bases it is assumed that the use of external images can help in developing mental representations more suited to science. From these references a necessary condition is to raise interpretative processes of the external image that may result in content knowledge.

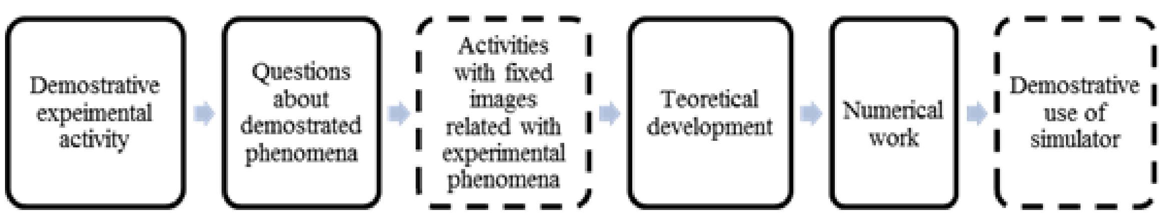

FIGURE 1. Phases of the didactic units, the two added modules are shown in dotted lines.

II. METHODOLOGY

The research was conducted in a group of a public high school in Mexico City, with 27 students of both sexes, ranging in age from 16 to 18 years. In an interview only about 10% of the students stated a vocational interest in the areas of mathematics or physics, and none of them looked at the physical and occupational choice. The style of the teacher shares features of traditional instruction although he is flexible.

The research was carried out in the units of Waves, Electricity and Magnetism. From the didactical point of view, each unit was originally divided into four phases that together constitute what we call a module. For purposes of the investigation, the modules were modified by adding two phases that led to the use of the image, inserting the first one between practical experience and theoretical development with the intention of establishing a bridge between them (Fig. 1). In the phase "activities with fixed images related with experimental phenomena" solution of questionnaires were carried out, where the central element was reading or drawing the image (photographs, diagrams or sketches). Each questionnaire addressed different aspects of both the knowledge and skills that the student need to use in the solution of the problems posed, from the gathering information of an external image to the creation of drawings. Also, in some cases students were asked to justify their answers. Once obtained, the student responses were analyzed and grouped for classification.

III. RESULTS

Case 1: Postulation of forces to explain the phenomena. Context: Representation of the electric field due to a charge of unknown sign.

Students were presented with a photograph of the pattern formed with grass seed by an electric charge of unknown sign and two vectorial schemes that represent the electric field due to a negative electrical charge and the electric field due to a positive charge, respectively. Students were asked to compare the photograph with the schemes and decide whether based on it, they can or not determine what kind of charge was associated with the pattern shown in it. In this case 65% (13/20) of the students expressed that it is possible to determine the type of charge with the given information and 35% (7/20) answered no. Only 28% (2/7) correct answers included a proper justification, referring to visual information as a basis for their argument (*e.g.* because in the photograph they cannot appreciate the direction of seeds). 56% (4/7) correct answers justification does not take into account the necessary visual information.

Among those who said that it is possible to determine the type of charge, up 62% (8/13) assumed or postulated a force or movement (attraction (5)/repulsion (3)) and hence deduce the sign of the charge and the effects:"It is negatively charged because the charges move grass inward", "It is positive charge, because in the images below is shown that a positive charge repels straws or they go in the opposite direction when the charge is negative".

Because the image is fixed, we believe that in this case the students retake elements created during the laboratory experience and add them to the information given in the questionnaire.

Case 2: Common language interfering on the interpretation of the question. Context: Frequency change in the representation of a refracted wave.

From the pictorial illustration of a refracted wave, obtained from the Internet (Fig. 2), students were asked to answer 4 questions and explain their answers about the relationship (greater than, less than, equal to) of the values of wave variables (length, velocity, and refractive index) between the two media. The percentages of correct answers (from the physical point of view) are: wavelength 89%; velocity 41%; frequency 0%; refraction index 70%. The highest percentage of correct answers (89%) was obtained for the relationship between wavelengths, which seems to correspond to the direct association between image and concept: link wavelength-distance between parallel lines, compare these distances and select the greater. However, none of the students (0%) had a completely correct answer, which would appeal to graphic information properly. 19% of students (5/27) mentioned the observed distance between crests (or valleys) and the comparison between these distances in the two cases, but made some mistakes or inaccuracies in the language. 22% (6/27) associated correctly with the visual element but made errors in their arguments: *because the size of the white stripes is larger*. Another 22% (6/27) confused the meaning of the terms in the common and scientific language: *The wavelength is greater because the disturbance is less frequent*. Here they use the term "frequent" as a feature of the spatial density pattern as is often used in Spanish. The remaining 33% (9/27) lacked justification, at least partially acceptable: *Since lines are skinnier, there is a higher wavelength*. One case (4%) appealed to a justification relating the media: *Due to the way the wave moves in the medium*. This justification is difficult to classify.

On the other hand, the question with a lower number of correct answers was that on the wave frequency. In this case, all students chose to select the medium 2 as one in which the wave is moving with more frequency; that means that none (0%) of students selected the correct answer (medium 1).Among the reasons given for choosing medium 2 was *the larger number of waves, i.e.,* greater spatial density (67% (18/27). 26% (7/27) justify from the shortest distance between stripes. The remaining 7% (2/27) is not justified.

We believe that in this case students are being influenced by the meaning given to the word frequency in everyday life, which is often associated with "more of ...." Thus, reading "where the frequency is higher" they read into "where there is more (waves)".

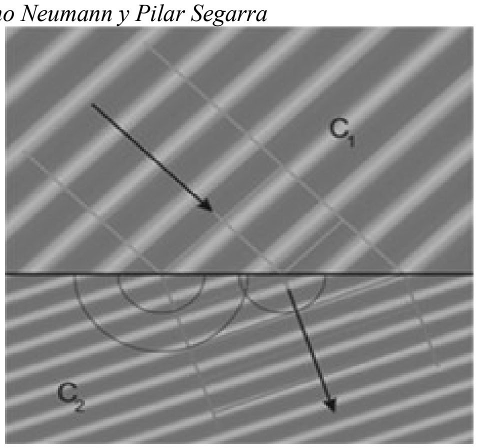

FIGURE 2. Illustration of refracted wave used as reference for the comparison of wave parameters in two media.

Case 3: Iconic rigidity. Context: Representation of circuits.

Students were presented with a series of drawings (pictorial representation) of electrical connections including the basic elements of a circuit (source, cables, battery). Although not used complex elements (capacitors, coils, etc.) some of the connections showed unusual shapes. In these cases answers which showed difficulty discarding unimportant geometric elements in the schematic representation were detected, such as cables, so that the students changed from the pictorial representation to the schematic one maintaining some geometric characteristics of the first. For example, for the following picture 40% of students made a sketch of the following type:

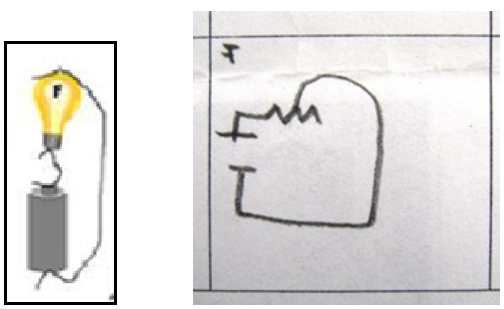

FIGURE 3. Pictorial reference and schematic representation done by a student.

The need to know and in some cases justify which of the elements represented in a degree of iconicity should stay and which not when changing to another degree of iconicity representing the same situation, is an aspect that should be worked from visual literacy.

Case 4: Influence of experience and confusion between cause and visible effect. Context: Representations of the distribution of the charge on the electric field due to a charged conductor.

A photograph showing the distribution of grass seeds embedded in a non-conductive liquid in which an electric field from a charged conductor had been created. Although in the photograph the charged conductor was a thin metal cylinder (not shown because of copyright), many of the students made sketches (left figure) which seem to correspond better with the laboratory experiment (right photograph).

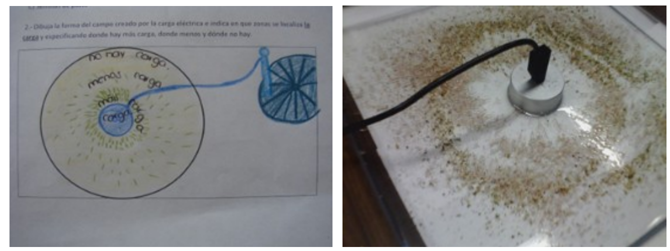

FIGURE 4. Photography of a electric field device and the pictorial representation drawing by student.

Confusion between the concepts of charge and field as well as between cause and effect were detected. Most of the students associated closeness to the conductor with the highest charge, linking the effect on seed to the charge and not to the field. Behind that it seems to be a conception of the charge as something leaving the conductor and pushing the seeds, being the conductor a source of charge. Also, many of them claimed that at the ends of the experimental device (away from the conductor) there was not charge (maybe because it did not reach there).

Case 5: Interference between two iconic representations. Context: Representation of resistance in an electrical circuit.

Some students represented in the same way resistance and wave. They see the same representation in both cases, not distinguishing characteristics that differentiate the graphics, or the contexts in which they apply.

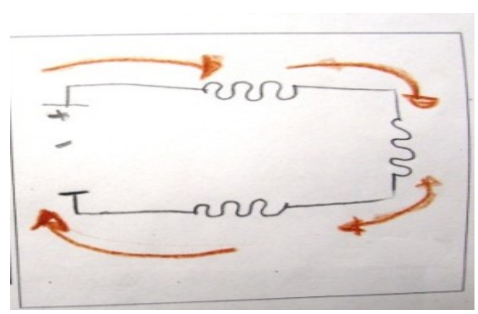

FIGURE 5. Pictorial representation of electric circuit elements showing the interference of wave representation.

In another case, some students used the same representation to draw the filament of a bulb and that used to represent resistance. When asking them about their drawing they were surprised about that in the circuit diagrams they did not draw the filament.

IV. CONCLUSIONS

In this first phase, the research allowed us to establish some of the problems that arose among students for the proper use of the image in physics high school courses.

The influence of "prior knowledge" from both the textual aspect of words (common meaning vs scientific meaning), and from the visual representations (meaning recovery of image of previous situations) seems to affect directly the reading done by students [9]. Also, they seem to make the interpretation of iconic representations considering the most concrete levels.

These aspects should be considered for planning activities in the next step.

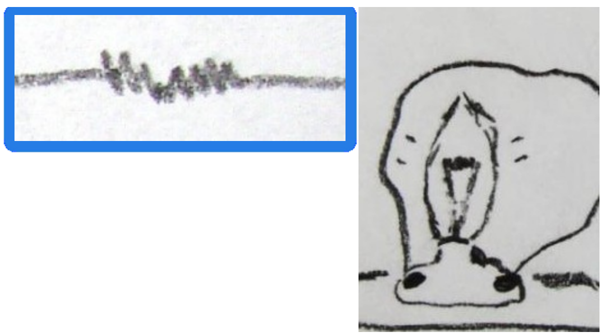

FIGURE 6. Schematic representation of electric resistance (left) and filament of a bulb (right), showing same iconic level between team.

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