Modifying high school students ideas about magnetic field concept

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Abstract

We present a study about magnetic field concept ideas of students enrolled in Mexican high schools. We administered a pre-test and a post-test using the evaluation instrument CSM, which is part of the Conceptual Survey on Electricity and Magnetism (CSEM) to the students from a public high school and to the students from a private school. Students answered questions about the magnetic field concept in the pretest and then performed experiments through collaborative work at the laboratory. Finally, students took a post-test, results obtained from students answers analysis, are presented at the end of this paper.

Keywords: Magnetic field concept, student ideas, evaluation instrument.

Resumen

Se presenta un estudio de las ideas que tienen los estudiantes de preparatorias mexicanas, acerca del concepto de campo magnético. Se aplicó un pre-test y un post-test usando el instrumento de evaluación CSM, que es parte de un examen conceptual de electricidad y magnetismo (CSEM), a estudiantes de una escuela pública y a estudiantes de una escuela privada. Los estudiantes contestaron preguntas acerca del concepto de campo magnético en el pre-test y luego realizaron experimentos en el laboratorio, por medio de trabajo colaborativo. Finalmente, los estudiantes presentaron un post-test, se presentan al final de este artículo, los resultados obtenidos del análisis de las respuestas de los estudiantes.

Palabras clave: Concepto de campo magnético, ideas de los estudiantes, instrumento de evaluación.

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I. INTRODUCTION

It is very important to know student ideas about magnetic field concept and observe how this ideas change after instruction. This knowledge about student ideas is related to the fact that teaching-learning process depends on two main factors: i) internal conditions or the cognitive level of the student and ii) external conditions or the learning environment [1]. That is why we must consider among other factors student ideas about the topic of interest.

For our study we worked with student groups from one public school and one private school. Three sessions of two hours were available for working with student groups. We selected some experiments, that let us to know student ideas while they were performing these experiments, writing observations and discussing about their conclusions from the experiments outcomes.

At the present time, participating schools use traditional instruction (mostly lecturing) during physics teaching. It has been reported by Physics Education Research, it is not an efficient teaching method for the students to learn [2, 3, 4]. For this reason, we are interested in studying how student ideas about magnetic field concept change when they perform intentional experiments at the laboratory.

We started our study by administering a pretest using a part of the CSEM multiple choice test [5] related to the magnetic field concept (*i.e.*, questions from 21 to 30), calling it CSM, in order to know student initial knowledge level and at the same time to detect their previous ideas that would allow us to design intentional laboratory experiments in order to deal with these ideas and change them. Then, we work with students at the laboratory, through interactive engagement and collaborative work. Students made experiments that allowed them to see magnetic field effects. After this, students took a post-test that allowed us to see how student ideas changed performing this experimental activities.

Finally, we analyzed student evaluation answers using normalized gain [6].

II. THEORETICAL FRAMEWORK

The goal of the intervention was to detect how students understand magnetic field concept, by providing students with an evaluation instrument (CSM) that would allow them to show their knowledge about magnetic field concept prior to instruction. Then performing laboratory activities, students could show their ideas about the concept based on concrete experiences. This approach allows students to start from concrete facts through guided experiences, posing their own questions [7, 8] and describing their observations in their own words, leading them to develop new ideas about the new concept [7].

A. Experiment selection and design

We selected experiment according to the work of Etkina *et al.* [8, 9, 10]. They present a different way to use experiments in physics classroom, similar to the ways experiments are used in physics research. They say "In traditional instruction students observe a phenomenon and then the teacher explains why it happened that way.

In active learning approach students predict the experimental results before performing an experiment using their prior knowledge and then perform the experiment and revise their reasoning or first observe the experiment, devise an explanation and then test this explanation in another experiment" [9].

Experiments used in this study, follow the logical sequence suggested by Etkina *et al.* [9]:

1) Observational experiment. The goal is to observe a new phenomenon. Students later devise explanations for the observations.
2) Testing experiment. The goal is to test whether the explanation devised for some observed phenomenon works. Students use explanations that they constructed to explain the results of type 1) experiment to predict an outcome of a new (type 2) experiment.

We selected the experiments and devised supporting questions accordingly to match the topic of magnetism and working context.

B. Collaborative work for observing student ideas about magnetic field concept

In order to study student ideas, we considered PER results in learning difficulties [11, 12, 13] and also PER results on collaborative work [13, 14, 15, 16]. We had only three sessions of two hours for working with students, so we decided to use collaborative work during laboratory sessions, organizing each experimental group in 4 or 5 student teams.

Experimental outcomes for different teams were observed. The teacher helped and supervised team work.

III. METHODOLOGY

To design the experiment sequence and contents, we chose the following goals, for studying the students ideas about magnetic field concept, based on PER results for learning goals [11]:

1) First goal is that the students show how their ideas about the concept of magnetic field lines of a bar magnet change.
2) The second goal is to see if the students identify magnetic field characteristics. Here we focus on magnetic dipoles, and the effects of magnetic field on a compass needle.
3) Finally, we want to know the idea that students have about a moving charge. They should show if they understand that it produces magnetic field.

At the end, students should show if they are capable to explain qualitatively, how: a moving charge, a current-carrying loop, a long rectilinear current-carrying wire, produce magnetic fields and describe the shape of the magnetic field lines.

After defining the above mentioned characteristics, we made worksheets, the purpose of worksheets was to guide students during observational and testing experiments. We designed two laboratory assignments to achieve goals 1-3 mentioned above.

IV. EXPERIMENT MAKING

The students were grouped in teams of four. The teacher asked them to name a leader, a secretary, and a narrator for each team, so that the leader could coordinate team work, the secretary could write team observations and the narrator could share with the other teams the observations obtained by his/her team by reading them aloud.

At the end of the laboratory session the teacher assigned homework for the next class.

The homework was to bring a report including a description of what they did during the lab and their personal conclusions. This report allowed us to see how students' ideas about magnetic field were, because student drawings and comments let us to know what they were thinking about magnetic field characteristics.

A. Students observations and experiments schematics

Now we show some of the student observations and schemes they did about experiments. Fig. 1 shows a student drawing for magnetic lines obtained using iron fillings and two round magnets. Magnets are placed with North Pole facing south pole. Student comments are: "this is the drawing of two magnets facing each other and as we can see, both magnets have iron fillings around them, but there were more iron fillings between them than in any other place".

FIGURE 1. Magnetic field lines when magnets are placed north pole facing a south pole.

In Fig. 2 it is shown a student drawing of a magnet effect on: a) metal pieces and b) paper and plastic pieces. Student comments are: a) set clips near a magnet yields: clips stick to the magnet; b) there is no attraction force between magnet and pieces of paper and plastic".

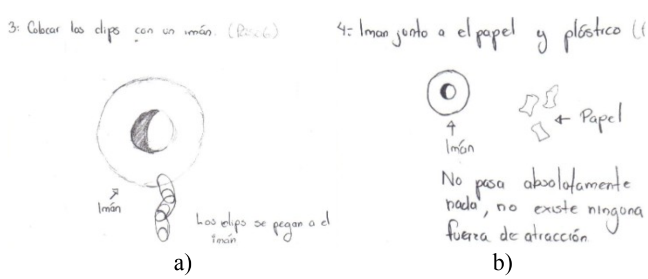

FIGURE 2. Magnetic field effect on a) metal; b) paper and plastic.

Below we show the results of evaluating the learning gain for CSM questions using the Hake normalized gain [6].

V. ANALYSIS OF RESULTS

The analysis of results [6, 17] revealed a significant change in student ideas. Specifically, we found the normalized gain of 0.77 for first experimental group.

Graphs below show pre-test results for first experimental group. Black bars show correct answers for each question.

Figs. 3 and 4, show the results achieved by the first experimental group. Note that 26 students took the pre-test and 22 students took the post-test evaluation. Fig. 5 shows correct answers for the pre-test and the post-test evaluation of the first experimental group.

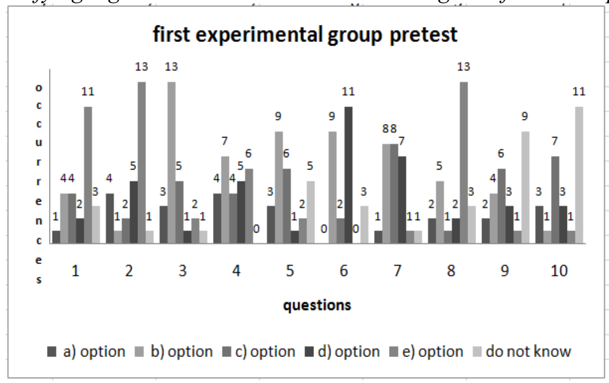

FIGURE 3. First experimental group pretest answers.

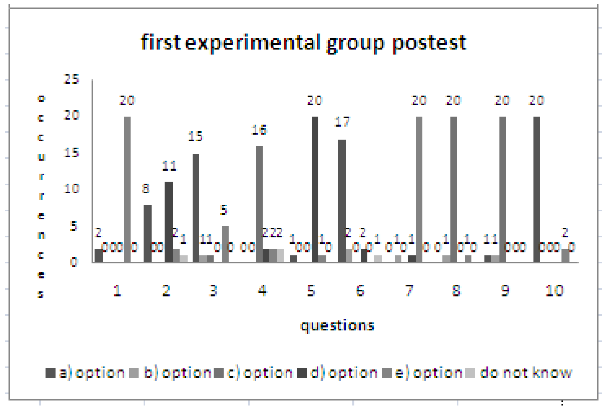

FIGURE 4. First experimental group postest answers.

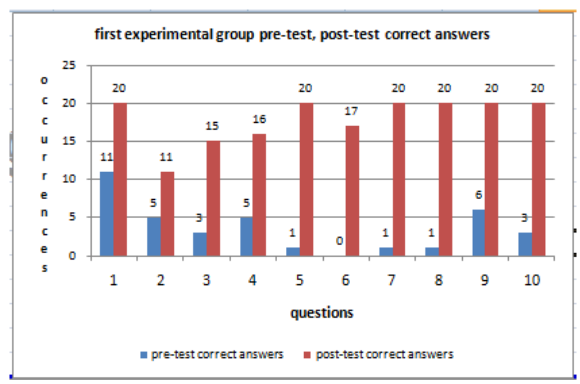

FIGURE 5. First experimental group pre-test and post-test correct answers.

Table I shows results for the first experimental group.

TABLE I. Pretest and Posttest Measurements for the first Student Experimental Group.

Evaluation Test	N	Mean	Percentage	n	P
Pretest	26	1.46	14.6	10	0.146
Posttest	22	8.1	81	10	0.81

Using Table I data, we can calculate normalized gain:

Normalized gain = (posttest%-pretest%)/(100%-pretest).

= (81-14.6)/(100-14.6)

=66.4/85.4=0.77.

We observed that normalized gain is very high and decided to use the same intervention in another high school in order to see if it yielded consistent measurements. For this intervention, we had a second experimental group called IBP. Figs. 6 and 7 below show the pre-test and post-test answers for IBP experimental group. Again, black bars correspond to correct answers.

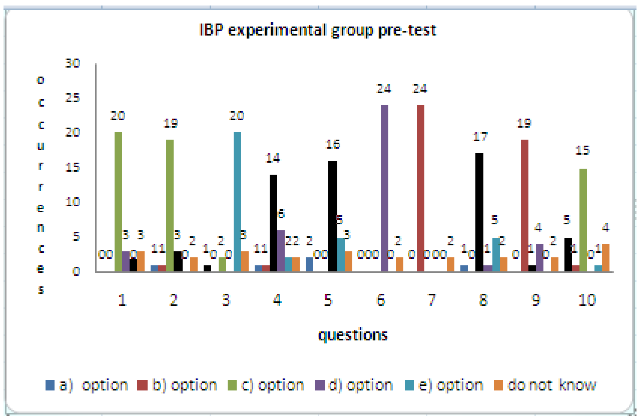

FIGURE 6. IBP experimental group pre-test answers.

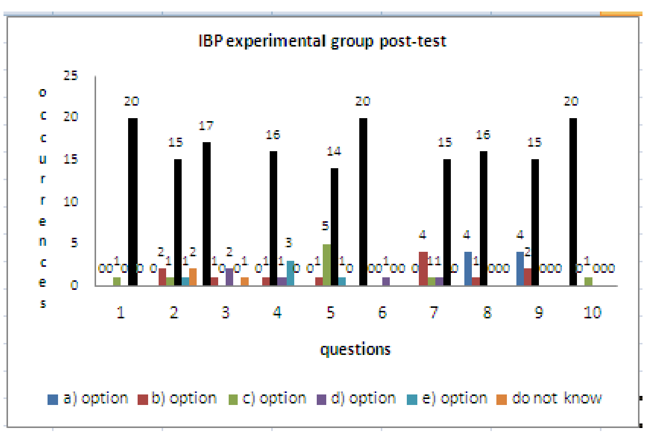

FIGURE 7. IBP experimental group post-test answers.

Fig. 8 shows pre-test and post-test correct answers for IBP experimental group.

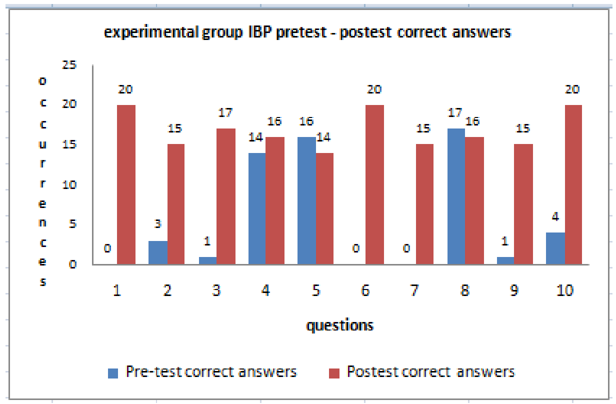

FIGURE 8. IBP experimental group pre-test and post-test correct answers.

Below Table II shows the results obtained for IBP experimental group.

TABLE II. Pretest and Posttest Measurements for IBP Student Experimental Group.

Evaluation Test	N	Mean	Percentage	n	P
Pretest	26	2.1	21	10	0.21
Posttest	21	8.0	80	10	0.80

From Table II results we obtained the normalized gain of 0.74 for second experimental group, which is also very high even for the PER-based instruction.

VI. CONCLUSIONS

We found that it was possible to change the ideas about the magnetic field concept of high school students through experiments making and collaborative work. We suggest that the methodology we used for working with the magnetic field concept could be used for the whole high school physics course to find if it produces similar results. Therefore we can proceed to structure the introductory physics courses following the strategy described here in order to help students in their conceptual comprehension of physical phenomena.

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