A new university introductory physics course in Venezuela

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A first semester introductory physics course was designed for the physics career students. These course changed the students attitude toward physics. The desertion rates, low grades, absenteeism and unpunctuality present in other courses of the career, were greatly improved.

Keywords: Introductory physics course

Se diseñó un curso introductorio de física para los estudiantes del primer semestre de la licenciatura en Física. Este curso cambió el sentimiento de los estudiantes hacia la física. La tasa de deserción, las bajas calificaciones, el ausentismo y la impuntualidad, comunes en otros cursos, se superaron enormemente.

Descriptores: Curso introductorio de física

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1. Introduction

In Venezuela is known [1–3], that senior year high school students have a poor and insufficient physics and matematics [4] background, in part due to low preparation and motivation of high school teachers which produces aversion to university physics courses. This leads to high desertion, low grades, absenteeism and prevalent unpunctuality. In La Universidad del Zulia (L.U.Z.), student enrollment begins with a national pre-inscription where they select three different professional careers in priority order, then they register for a general and selective exam. Because there are more places offered than students interested in pursuing a physics career, L.U.Z. assigns non-interested ones in order to fill the physics career seats [5].

Due to this situation, our department prepared a new introductory physics course, which should be more encouraging to most pupils. Students arrive at the university with non-scientific preconceptions, which are incomplete, fragmented and often erroneous knowledge [6], these misconceptions are inconsistent with the physical world, provoking misunderstanding and aversion to the physics courses. The goal of this course is to remove most of the students preconceptions in order to change their attitude toward physics.

This is a course with practical work (simple experiments, audio-visuals, homemade experiments and analysis about daily life experience situations) and should be stimulant by itself. However this is not sufficient, and needs to encourage debate and discussion among the students, complemented by questions introduced by the teacher, directed to confront their "naive theories" with scientific concepts [6]. The study reported here corresponds to an introductory physics course initially given during the second semester in 1995, and taken by first semester students of the physics career.

2. About the course

An introductory physics course should have characteristics that motivate students to the great adventure of discovering the physical world. For this reason, the course was designed applying the following strategies:

a. Exploring the physical world through programmed experiences [7].

b. Discovering student capacities to understand the physical phenomena by themselves [8].

c. Finding partners that help each other during the learning process [7, 8].

d. Breaking the traditional physics scheme, which does not relate to their daily life [9, 10].

The course was divided in three groups (A, B and C). Group A was formed by 24 students that selected physics as first choice, group B by 23 students with physics as second choice and group C by 24 students that did not select physics. Each group contained three sub-groups, which worked on different tables and with different equipment, so that each student could participate in the laboratory practices. Small groups offer opportunities for every student to raise questions freely, to discuss and argue about different views, and consider matters of common interest [7].

The course topics involve those from high school physics courses and some contemporary contents [11]. The reasons why those contents were chosen are that the main preconceptions are acquired during their high school courses and also in their daily life introduced by massive communication means, *i.e.* themes like lasers, optical fiber, satellite communications, etc.

The themes course are: time, space, movement, dynamics, gravitation, collisions, work and energy, power and

energy conservation, gases and temperature, heat, electric charge, potential and electric field, electric current and magnetic field, electromagnetic induction and electric circuits, waves, light, atoms.

All students had received three levels of high school physics courses. Students took the course twice a week in a two-hour session, during fourteen weeks. Each session was managed by a guide. The teaching staff consisted on three teachers, three assistants and a coordinator. Each group was attended by a teacher plus an assistant selected for their personal interest and enthusiasm in teaching the new course.

Students used study guides during the working laboratory class. The guides were designed applying four characteristics: The first part related to daily life experience situations [10], the second part referred to a projected film or a demonstrative experiment, the third part contained commentaries and conclusions, and the last one proposed an investigative homework about the guides theme or a homemade experiment.

Experiments used in the different guides and the relations with the themes were:

— Human reaction time (time).

— Measuring different lengths with different instruments (space).

— Uniform and uniformly accelerated motion. Analyzing air track strips (movement I).

— Acceleration due to gravity. Steel ball launched from a ramp toward a marketable vertical strip (movement II).

— Inertial cars pushed by springs (dynamics I).

— Studying the friction with an inclined plane (dynamics II).

— Explosion with two inertial cars (collisions).

— Measuring forces in an inclined plane. Potential energy storage (work and energy).

— Launching projectiles with a rubber band. Holding heavy things (power and energy conservation).

— Boyle and Charles laws. Boiling and melting point (gases and temperature).

— Heat capacity and conduction in several materials (heat).

— Producing electric charge by friction (electric charge).

— Working with the electric field plotting set (potential and electric field).

— The current generator and electric motor. Forces between currents (electric current).

— Magnets. Magnetic fields with iron filings (magnetic field).

— Electromagnetic induction with coils, galvanometer and magnets (electromagnetic induction).

— Series and parallel circuits (electric circuits).

— Water waves in a ripple tank (waves I).

— Sound waves traveling through different media. Electromagnetic waves with two circuits (waves II).

— Light beam, prisms, soap bubbles, slit diffraction (light I).

— Mirrors and lens (light II).

— Cathode ray tube (atoms).

Through a laboratory experiment or a projected film, one problem is presented to the students. Some guide questions lead student attention toward the equipment and the phenomenon involved. Questions about which variables can be measured and what instrument ought to be chosen are frequently used to raise students concentration on the problem. A few questions at the beginning of the guide, were made about daily life situations related to the phenomenon with the purpose of encouraging students to try to solve the problem. At this stage, they start "to live" the physics.

Students share their measurements among themselves prompted by the teacher in order to find the coincidences and differences. Different or equivalent measures provoke a controversy among the students, which is fomented by the teacher and assistant trying to conduct them toward a reasonable answer. At this stage, students find partners during the learning process.

Typical answers like: "That was so easy!" or "!Look, this was the reason that thing happened!", showed the new student feelings about physics. At this stage, they start to discover their capacity to understand physical phenomena. This last aspect was measured through the homemade experiment or investigative homework reports. Such homemade experiments were designed to be made with accessible and recycle materials [12] which are enough to show the phenomenon involved. Homework assignments were graded in the traditional form.

The core of some guides was a demonstrative experiment or a projected film. Such experiments were done with the conventional general physics equipment and a few were home built. Data acquisition by the students was only important for the qualitative relationship between the physics variables involved.

Attendance was taken at the beginning of each session. Student lab work was evaluated according to the following criteria: *a*) participation in discussion, *b*) coherence of the whole answers, and *c*) completeness of the guide. This evaluation was scored from 1 to 20, and it represented 70% of the total grade. The remaining percent (30%) was evaluated through homework reports.

TABLE I. Class attendance for each group.

Groups	Attendance (Percentage)		
	0 absence	Up to 1 absence	Up to 2 absence
A	60%	73%	86%
B	50%	64%	69%
C	45%	65%	80%

TABLE II. Desertion by group.

Groups	Number of inscribed students	Number of deserters	
		At the beginning of semester	During the semester
A	24	5	2
B	23	3	0
C	24	4	0
Total	71	12	2

Two surveys were applied during the last week of the course. The first one was a 43-question institutional test with three outstanding questions about the course results. They were: 1) Would you like to take another course with the same teacher?, 2) As a result of this course, do you have more interest in the physics field?, 3) Have your expectations been satisfied with this course?. The other survey was a seven-question internal test with two outstanding questions relative to their feelings about physics before and after this course. Since these answers had a subjective charge, they were analyzed classifying each answer according to the following criteria: One point for nothing favorable, two points for little favorable, three points for indifferent, four points for favorable and five points for greatly favorable. Forty-five students filled out the internal test and five staff members classified the answers using the above criteria. These points were added question by question, and averages obtained dividing by five, which are reported as the results.

Weekly sessions about the guides were called by the teaching staff, during which critical evaluations were made in order to correct any orientation problems.

3. Results

Class attendance is one of the most important variables of these surveys, because it is a measure of the student's motivation and interest in the course. It is very important to point out that in the department of physics average class absenteeism is very high. Table I gives class attendance by percentage for each course. In general, in our courses, 80% of the students have assisted to 90% of the programmed activities. High motivation has been noted, demonstred by the punctuality of the students and the curiosity awakened during the development of the experiences. Class attendance on average, was maintained even though some adverse situations such as strikes and demonstrations made access to the University difficult.

TABLE III. Average grades by group.

Groups	Average grades	σ
A	18.4/20	1.8
B	19.5/20	0.9
C	16.7/20	2.5

TABLE IV. Institutional test-question 1.

Would you like to take another course with the same teacher?	Yes	No	None
A	14	0	0
B	10	7	0
C	16	0	2
Total	40	7	2

Desertion rate was relatively low reaching only 20% of the 71 students (see Table II). It is important to point out that the highest number of desertions occurred at the beginning of the semester (17%), but this represents those students who inscribed the course but never assisted. Once the course started, the desertion rate was only 3%.

Class dynamics, allowed for active student participation such as answering the guides, showing high enthusiasm in raising question and expressing their views, although sometimes, these differed greatly from the physical foundations.

Table III shows the average grades by group with their respective standard deviations. Groups A and B got higher grades, while group C got acceptable ones, although it was constituted by students who not only didn't want to study physics but also felt some aversion for it.

TABLE V. Institutional test-question 2.

As a result of this course, do you have more interest in the physics' field?	Yes	No	None
A	13	1	0
B	13	3	1
C	13	3	2
Total	39	7	3

TABLE VI. Institutional test-question 3.

Have your expectations been satisfied with this course?	Yes	No	None
A	14	0	0
B	11	4	2
C	17	0	1
Total	42	4	3

Generally the homework done by the students was very good, except in group C where it was closer to average due to the group's characteristics mentioned above.

From Table IV, 81.6% of the students interviewed answered positively. This suggests that the class dynamics used by the teacher during the course was adequate enough to motivate the students.

The results given in Table V and Table VIII, ratify that the class dynamic followed not only motivated the students but also awakened their interest in physics. From Table V, 79.6% of all students answered positively while 14.2% answered negatively, but, these negative answers came from groups B and C whose students have medium or no interest in physics.

Table VI emphasizes the results shown in the other tables. 85.7% of all students answered positively, being interesting to note that 40.4% of the positive answers corresponded to group C students which presented a high reluctance for physics studies at the beginning of the semester.

TABLE VII. Internal test-question 1. Feelings about Physics before the course.

Answer	Average
No favorable	19
Little favorable	9
Indifferent	8
Favorable	7
Greatly favorable	3

TABLE VIII. Internal test -question 5. Feelings about Physics after the course.

Answer	Average
No favorable	0
Little favorable	0
Indifferent	1
Favorable	27
Greatly favorable	17

Tables VII and VIII show the average answer to questions 1 and 5 of the internal test. Comparing these results we observe that students' feelings about physics made a change, showing a more positive feeling about it after the course.

4. Conclusions

A novel Introductory physics course offered by the physics department of La Universidad del Zulia, showed very interesting results: students' feeling about physics changed from negative to positive; they arrived on time to the classroom and were present in the majority of the sessions. Course desertion rate was lower than those present in other courses.

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1. J.M. Vence, Monography, *La elección de carrera: Análisis crítico de la problemática del estudiante venezolano de 5to año de bachillerato en ciencias y humanidades de los liceos públicos de la ciudad de Maracaibo.* (Universidad del Zulia, 1989).
2. I. Poleo *et. al.*, Graduate Thesis, Universidad del Zulia, (1991).
3. A. Di Bello, Monography, *Nivel de conocimiento de: Matemática y física de educación, actitud hacia dichas asignaturas y rendimiento en física del ciclo básico del Colegio Universitario de Cabimas.* (Universidad del Zulia, 1987).
4. N. Hernández *et. al.*, Graduate Thesis, Universidad del Zulia, (1987).
5. A. Montoya, Monography, *Estudio de rendimiento académico.* (Universidad del Zulia, 1970).
6. J.P. Mestre, *Phys. Today* **44** (1991) 56.
7. Su Gang, *Phys. Teach.* **33** (1995) 346.
8. Richard R. Hake, *Phys. Today* **44** (1991) 110.
9. Ervin Poduska, and Vincent Lunetta, *Phys. Educ.* **19** (1984) 241.
10. Alvin M. Saperstein, *Phys. Teach.* **33** (1995) 26.
11. Aubrecht Gordon, *Am. J. Phys.* **57** (1989) 352.
12. *Physical Science Study Committee (PSSC)*, (Physics, D.C. Heath and company, Boston, 1966).