



Why does it seem that my students do not understand physics courses?

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Abstract

For the past six years our freshmen fail the standardized (departmental) assessments in a very high degree. Several studies about this phenomenon have been carried out in order to find possible causes. Some conclusions have been found and they seem to explain it. The first cause is, as expected, apathy and the lack of interest of our students for anything but their cell phones. Then, by trying to understand why this happens, we have been looking for alternate educational models that take into account the following facets: (a) our students belong to the so called Net Generation (Net Gen); (b) their ideas and beliefs about physics, scientists, and the world functioning are obsolete and/or mistaken; (c) contents and curricular organization are not agreeable to the current global reality; (d) topic sequence in physics courses are not the best in some cases to promote skill development and to overcome conceptual inaccuracies; (e) current didactic strategies and models are not adequate for our Net Gen students; and (f) faculty must recognize their own limitations so they could improve their practice, and walk along the time's rate of change in order to promote learning. As a result we present an alternate educational model which has been tested to foster learning, develop intellectual skills and overcome conceptual inaccuracies. The main aspects of such a model are: (a) it is based on the last findings in neuroscience related to the learning brain; (b) takes into account the most important characteristics of the Net Gen; (c) brings another way to organize curricular content; and (d) promotes an alternate vision on the teacher's performance. The teacher is supposed to promote the required educational changes to educate their students so they can do better in this 21st Century globalized world.

Keywords: Physics teaching, Net Generation, Neuropedagogy, Curricula and evaluation.

Resumen

A lo largo de los últimos seis años, el índice de reprobación en los exámenes estandarizados (departamentales) de Física es excesivamente alto entre los estudiantes de primer ingreso a nuestra Universidad. Se han realizado diversos estudios sobre las posibles causas del fenómeno de los que se ha llegado a algunas conclusiones que lo explican. La causa primera se refiere a la manifiesta falta de interés y apatía de los propios estudiantes. A su vez, llegar a comprender el porqué de ello, ha llevado a buscar formas innovadoras de enseñanza que tomen en cuenta los siguientes aspectos: (a) nuestros estudiantes pertenecen a la llamada Generación Net; (b) las ideas y creencias con las que llegan al nivel superior son en su mayoría, obsoletas y/o erróneas; (c) los contenidos y planes de estudio no responden a la realidad global actual; (d) en un buen número de casos la organización de los contenidos, esto es, las secuencias temáticas, tampoco son apropiadas para el desarrollo de habilidades y la superación de errores conceptuales; (e) los modelos didácticos en uso no responden a las necesidades de los estudiantes; (f) el profesorado necesita reconocer sus limitaciones para superarse, caminar al ritmo de la época y lograr que sus estudiantes aprendan. De acuerdo con esto, se presenta un modelo educativo que ha mostrado efectividad para desarrollar habilidades y superar errores conceptuales en estudiantes de primer ingreso a la Universidad cuyas características son: (a) se fundamenta en los últimos descubrimientos sobre el funcionamiento del cerebro con relación al aprendizaje; (b) toma en consideración las particularidades de la Generación Net; (c) introduce otra forma de enfocar los contenidos curriculares; y (d) induce una visión alternativa sobre el papel del profesor, quien ha de ser el artífice de los cambios educativos y de la formación de sus estudiantes en el mundo globalizado del siglo XXI.

Palabras clave: Enseñanza de la Física, Generación Net, Neuropedagogía, Currículo y evaluación.

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I. INTRODUCTION

Introductory physics courses seem to be far beyond comprehension for most of our freshmen. The past six to ten years, students failed standardized departmental exams and the overall results showed us that learners have not understood neither physics contents nor they have learned (memorized) the few concepts, definitions and formulas to be used in solving exam problems. Three years ago we conducted a project with the purpose to elucidate possible causes and explain the flunk out phenomenon [1]. It was found that teaching style –the way and methodology the teacher uses–, is not a likely cause because four quite different teaching styles yielded fairly same results in departmental exams. But it was noticed by direct observation in the classroom that students were not interested in what the teacher was doing or saying, and the last year of observation it seemed that their main interest was their cell phones, and all over last year, it was Facebook and Twitter.

Another project was conducted to target only students. We designed two questionnaires based upon previous studies on what is currently known as the Net Generation (Net Gen) [2], and we found out that our teaching styles, resources and facilities are not what students expect. It became evident that we need to change our view of teaching focusing in what the new generations need and want [3]. In 2007 it was also noticed that our educational models were not compatible, at some extent, with the last findings in neuroscience [4].

All of these studies on student performance and teacher educational style were the foundations for an innovative teaching strategy that combines Net Gen features, neuropedagogy and reorganization of curricular contents. This teaching viewpoint requires changing the teacher's role in order to fit the social, educational and technological changes. In the next sections the results of above studies are briefly described and then, it is presented our new pedagogical strategy.

II. THE FLUNK OUT PROBLEM

At our universities we have a grading system composed of two or three departmental standardized exams. During the last six years, the failing index –that's what we called a percentage of flunk out students– was 100% as an average for the course *Introducción a la Física* (Introduction to Physics) taught in the first semester for science and engineering majors. After a two year project consisting in classroom observation, exam and grades analysis and interviewing students, we concluded that teaching style was not an actual influence on student performance, but we also found out that exams were not always written properly, did not cover curricular contents and sometimes they ignore course objectives [1]. A year later, we observed that modifying exam design and improving wording did not improve grades and/or student performance. But from interviews, we found out that most of students (around 80%

of them) said that class were boring, and those contents taught were useless and sometimes confusing. We then decided to implement a new project in order to look for other variables influencing learning and flunk out problem.

III. THE NET GEN FEATURES OF OUR LEARNERS

It became clear that there were this other feature we were missing. Our students belong to a new generation of people extremely different from our own generation. We learned that we are dealing with the Net Generation (Net Gen). Net Gen is a generalized worldwide phenomenon and people who belong to it, have also different ways to face learning, different attitudes and different expectations; in a few words, Net Gen learners are completely different from our former students say, in the early 90's. The book by Oblinger and Oblinger [2] is one of basic ones to understand the so called Net Gen. This new generation is described and its main features are:

- a. Environments in which multimedia is dominant. Rather visual items to watch than text to read.
- b. Learners want to get involved in active tasks; they would not like reading or writing about events.
- c. Motivation for learning rises from active participation in the teaching-learning process.
- d. An immediate answer is expected to every action. Technology provides almost instant answers.
- e. Orientated to results; clear and fast ones.
- f. They like team work. Learning by discovery is the better way for them to learn rather than listening to teacher lecture.
- g. Social interaction is an important component of learning.
- h. Multitask is a special feature. They can pay attention to two or three different activities; for instance they can be chatting, listening to music and making his/her homework in the computer simultaneously.

With these and some other features, we designed a questionnaire to make a Net Gen Profile for our students and we found out that they have almost all of the features than Net Gen learners from other countries. We think that a particular finding is: our students do not want full time lectures. Their preference is a class session 50% interactive, 50% lecture. We then thought that Net Gen features were the missing piece in the puzzle so the pedagogical strategy must take it into account.

IV. NEUROSCIENCE AND EDUCATION

The second component of the pedagogical strategy is a combination of neuroscientific discoveries and education. It is also called neuropedagogy. Literature on the subject is abundant and a good review is found in reference 4. It will be only mentioned the useful results for our pedagogical strategy. First of all it is recognized that the brain is the learning organ and that it can only learn if it is treated the way it naturally works. Some results obtained in the late

VI. TEACHER'S ROLE

Oblinger and Oblinger say that the first condition for a successful teaching (and learning) is: the teacher must accept that the new learner generation is completely different from any other generation in the history of education. Information and Communication Technologies (ICT) have made a different world for our students, and as consequence they are changing higher education. So we have to begin with the following questions: Who are our learners? How are today's learners different from faculty/administrators? What learning activities are most engaging for learners? Are there ways to use ICT to make learning more successful?

VII. THE PEDAGOGICAL STRATEGY

The pedagogical strategy we are proposing has four components: theoretical principles, subject contents sequence, special activities and assessment. Let's go a bit deep into them. Figure 1 shows the loop for our strategy.

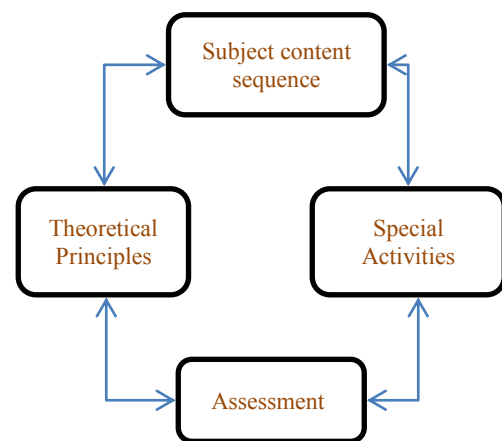


Figure 1. Pedagogical Strategy

The *theoretical principles* are definitions, laws, theorems, equations, etc. needed for studying any particular item. Learners are compelled to acquire them by using constructivist strategies [10], including cooperative/collaborative teams. Second component, *subject contents sequence* implies overcoming traditional sequences as exemplified above in Electromagnetism and Mechanics. *Special Activities* means that we are using some activities involving ICT, visiting museums and/or amusement parks, demonstrations and videos. We have used Facebook to keep in touch with students and exchange information, as well as a wiki to construct answers to elaborated problems. *Assessment* is a formative activity carried out in every class session. In our educational model, assessment means a kind of evaluating not only how much are learners learning, but *how well* they learn. Learning processes are as important as results (output) in the teaching-learning process. In this context, feedback turns to be the cornerstone of process. Testing (as in quizzes,

90's show that constructivist methodology as well as some behaviorist technics are compatible with the natural functioning of brain [5]. But it has also been shown that the main features of learning are emotions. So, a bit of stress (not threat), combined with suspense and joy will do better than just a flat lecture [6].

Our pedagogical strategy is begins with a definition specially fitted for our purposes: *Learning is a process which consists of appropriation (assimilation) of knowledge. This appropriation leads to changing behavior. The changes are relatively permanent.* This definition means that changes in observable behavior are necessary conditions to speak of real and significant learning. Changes in behavior comprise (among many other ones): wording, correct use of concepts, and efficient time management. These behavioral changes are the result of structural changes in the brain [7], so our strategy tries to promote these changes by exercising the brain.

V. REORGANIZATION OF CURRICULAR CONTENTS

The last component of our pedagogical strategy is reorganization of curricular contents. As we try to develop intellectual skills, such as mastering algebraic manipulation, deductive-inductive thinking and ability to explain concepts, we proposed a first hypothesis for a research project in electromagnetism: by changing the traditional order of curricular contents, learning will be fostered and some intellectual skills will be developed [8]. Changing the traditional order of contents were followed by a new teaching methodology consisted, mainly, of using analogies. As an example, the first unit is electric interaction. Columb's Law is introduced in two fashions: by analogy with Newton's Universal Law of Gravitation and experimentally induced at lab. We then move to some applications and define Electric Field (There are many details and mathematics issues but we do not expose the whole subject matter here). Second unit is now magnetic interaction, which is constructed by analogy with cylindrical symmetry for charge distributions. Current is defined and the force per length unit is constructed. In a similar fashion, magnetic field is defined. With this strategy we achieved the goal of lowering the failing index from 85% to 40% in standardized exams.

The next step was to change curricular contents in the course *Introducción a la Física* already mentioned. As for the case in Electromagnetism, changes in contents are accompanied by changes in pedagogical strategies. This changes and the implementation are completely new (for us); this is the first time that results of this project are socialized. We are proposing change the order in the teaching of Newton's Laws, to begin with defining interactions and begin with Third Law; then Second law and ending with First Law. We have tried these contents out to obtain excellent results [9].

exams, interviews, etc.) feedbacks teacher; then he/she makes decisions about possible changes in the process. Using the results, the teacher can feedback his/her students. The teacher advises their students, and then they can also change their learning strategies, conceptualizations, solving problem strategies, and/or attitudes. After some other activities, the teacher assesses again and the feedback cycle continues.

VIII. CONCLUSIONS

When I first asked why my does not seem to understand what I was teaching them, the unanimous answer was: “they do not study as hard as they should”. Right. But that is just one facet of the learning problem. Learners do not seem to understand physics courses mainly because they belong to a new generation of people whose interest resides on technology, and because they belong also to a global society ruled by a different set of values. Higher education has always been a complex task, but nowadays its complexity has increased. Student’s attitudes towards science –at least in my Universities– are not as good as we, physics teachers expect. Quoting a colleague, “high school spoils students to the extent that they see math and physics as their worst nightmare”. But also they think of science as having no applications to the real world; it is just only a bunch of formulae and definitions to learn in order to get good grades.

After a few years of searching for an answer to our initial question, we found out that any pedagogical strategy or educational model has to take into account, at least, the four issues we mentioned in section VII. Of course each one of these is composed of many more activities. I think it should be considered as an educational model under construction and development and has to be modified each time a new discovery be made. I also think that –maybe– the most important issue is changing the traditional sequence of subject matters mainly because our students have seen almost all of it in previous stages of our educational system. Misconceptions and wrong beliefs could be then surpassed by having a different focusing in everyday contexts with well-organized and consistent knowledge.

In our universities a high percentage of faculty are not aware of existence of pedagogical models or teaching strategies. Their practice could be considered as linear or traditional. We have developed this strategy as an

alternative to traditional practice; we have tested it with excellent results. We expect that it could be adopted so teacher training programs could be carried out. The beneficiaries will be our learners. I know it is not too late and I hope many more teachers will join us.

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