

# Potentiality of an integrated approach to teach the topic *Improving Life on Earth* to 9th grade students of Physical and Natural Sciences

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**Abstract.** This research had the following objective: to develop a didactical approach to teach the topic *Improving Life on Earth* including concepts of Physical and Natural Sciences, by using the strategy of problem-solving. We proceed to a comparison of the efficacy of an integrated teaching approach when compared to the conventional disciplinary approach.

The experimental design of the study included two 9th grade classes with 46 students. The treatment group was taught the topic with an integrated approach and the control group was exposed to the disciplinary approach.

Preliminary results indicate that the integrated approach to teach science is efficient in developing learning skills and the interrelation of scientific concepts.

**Keywords.** Problem-solving based learning, integrated science teaching

## 1. Introduction

The disciplinary model that has persisted in the Portuguese Educational System seems to have failed to deliver citizens capable of entering the labor market as well as an active and responsible participation in social life. To contribute to an integral education experience for his students, a teacher must go beyond the borders of his subject matter and look at science with a multiplicity of viewpoints. Therefore,

problems must be approached in an integrated way, by using teaching methods that promote the students' critical thinking and, consequently, their capacity for autonomous decision-making [2]. We need to see science teaching in an integrated way in order to relate scientific concepts, as reality does not function in isolated parts but as part of a complex web of interdependencies. The strict disciplinary approach implies a narrow and partial view of reality. Integrated approaches promote a better comprehension of phenomena and problems, while promoting a critical and inquiring mind. Furthermore, problem-solving based learning, promotes, according to Margedson [2], a better understanding of reality while facilitating the integration of learning of different disciplines. Knowledge, regardless of the subject matter it belongs to, is identified during the process of problem solving as opposed to being previously determined. It was in this context that we decided to plan an integrated teaching approach for physical and natural sciences, taking into account the current Curricular Guidelines [5].

The focus of our study was on the development and evaluation of a teaching approach that not only integrated the contents of Physical and Natural Sciences related to the topic "Improving Life on Earth", but also emphasized teaching strategies for problem-solving based learning.

## 2. Research methods

The research consisted of an experimental study to compare the initial and final stages of a sample of 9th grade students divided into a treatment and a control group. An integrated approach was used with the treatment group and a disciplinary approach was used with the control group. The two teaching approaches were compared in terms of developing students' skills, namely at the level of interrelating scientific concepts, problem-solving and the promotion of an holistic view of the following topics: quality of life, road safety, options for a balanced health behavior and actions to promote the health quality of the community. We also tried to promote in the students the development of discussion skills and a more conscientious stand that fosters active and participative citizens.

## 3. Teaching methodology

In the control group, we opted for a conventional teaching methodology given that this was the only one known by the teacher of Natural Sciences. Thus, in Physics and Chemistry we started with the following concepts: road safety, movement, frame of reference, trajectory, average velocity and instant velocity; in the discipline of General Sciences we covered the following contents: indicators of the health status of the population, measures to promote health and prevent alcoholism. The latter were used to solve practical problems.

Though the teaching was centered in the teachers, the discussions and the exchange of ideas abounded given the nature of the topics address. This favored the restructuring of some alternative conceptions.

The treatment group was exposed to a methodology that was guided towards learning based on problem solving [3], as a vehicle to the integration of knowledge we wanted to achieve. We sought contexts related to news articles extracted from magazines and periodicals, one related to the environment and the other one fictitious, based on a road accident. The goal was to develop competencies at the level of understanding reality and solving problems, and at the level of citizenship given that an informed citizen ought to be able to analyze information originating from any field of knowledge [5]. This is especially the case concerning information made available by the different media. The role

of the teachers was to assist students in overcoming obstacles and to answer clarification questions. As they related to the problem-solving process, knowledge of Physical and Natural Sciences was introduced or researched.

Each group of students was given a worksheet that included the aforementioned concepts, which asked them to posit problems they thought were important to solve. The groups defined the following problems according to the two disciplines under study (Table 1).

**Table 1- Problems defined by students.**

Group	Subject	Problem
1	Natural Sciences	How can we reduce the pollution caused by traffic in the city?
	Physical Sciences	What are the causes of traffic accidents?
2	Natural Sciences	How does alcohol affect the human body?
	Physical Sciences	Why is alcohol one of the main reasons for traffic accidents?
3	Natural Sciences	Which institutions are devoted to the treatment of alcoholism and how do they do it?
	Physical Sciences	What is the relationship between speeding and accidents?
4	Natural Sciences	Which drugs can affect your capacity to drive?
	Physical Sciences	How does the seat belt work in case of accident?
5	Natural Sciences	What is the opinion of citizens regarding the effect of alcoholism on human behavior in the cities where students live?
	Physical Sciences	What is the opinion of citizens on the causes of traffic accidents and the measures that ought to be taken in the cities where students live?
6	Natural Sciences	What are the causes of pollution in the cities where students live?
	Physical Sciences	What is a measure of safety distance?

The teaching and learning process developed in the following phases as shown in Table 2.

Sources of research: internet, library, population in students' cities, newspapers, journals, CD-ROMS, books, textbooks, bus drivers and policemen

## 4. Sample of students

The study involved 46 students, between the ages of 13 and 15, from two classes in the ninth grade from a school located in Northern Portugal. Students in this school shared similar socio-economic and cultural characteristics. They all belonged to middle to low income families, with all parents – with the exception of one student- being fully employed in a technical or factory type of job. The groups under study were selected due to their similar socio-economic characteristics and because they were taught by the teachers participating in the study.

**Table 2. Phases in the process of teaching and learning**

Phase	Curricular Area	Activities
1. Defining Problems	Physical Sciences	Defining the problems raised by the situations under hand
2. Deconstructing the problem	Physical Sciences and Natural Sciences	Deconstructing questions in order to assist the problem-solving process.
3. Problem solving	Physical Sciences and Natural Sciences Guided study Civic Training Portuguese Language	<b>Planning:</b> defining strategies, possible sources of information, distribution of tasks. <b>Research:</b> information gathering in several local sources <b>Implementation:</b> Selection and organization of the information available, interpreting results, finding solutions and applications to other contexts.
4. Presentation and discussion of results	Physical and Natural Sciences	
5. Synthesis and evaluation of the process	Physical and Natural Sciences Civic Training	Synthesis of the results and evaluation of the problem solving process.

## 5. Description of the study

The study was organized in the following way:

1 – The teacher-researchers reorganized the contents of the relevant subjects under the topic of *Improving Life on Earth*, in accordance with the Curricular Guidelines.

Due to problems of scheduling, we circumscribed the study to contents related to the sub-topics: Equilibrium in the Human Body – options that interfere with the equilibrium of the human body; Individual and Community Health-Measures to promote health (Natural Sciences); and Road Safety and Movement (Physical Sciences), with special emphasis on the issues of alcoholism and environmental preservation.

2 – The researchers devised three plans: two for each disciplinary approach (Natural Sciences and Physics and Chemistry) and the third one integrating a common approach to both disciplines.

3 – Selection and characterization of the cultural and socio-economic background of the students.

4 – Data collection.

5 – Analysis of the results (learning and students' reactions) using combined qualitative and quantitative methods.

## 6. Data collection and processing

The efficacy of each approach, in terms of the development of students' competencies and their reactions, were evaluated through the results of the tests (pre and post tests) and direct observation taking into consideration their interest and efforts (Table 3).

The questionnaire was adapted from Gandra [3], considering the contents under study and the school context in which it was applied.

The goals were to assess the development of students' competencies concerning the topic of *Improving Life on Earth*. The questionnaire was particularly aimed at testing discussion and problem-solving skills as well as their ability to become active and engaged citizens.

The questionnaire consisted of six questions related to the respective disciplines as well as non-disciplinary contents of an area of project called Guided Study and Civic Training. Following its adaptation, the questionnaire was validated by three specialists in Science Education.

We proceeded to a qualitative analysis of the teachers' journals to detect students' reactions to both methodologies. The quantitative analysis [1] concerned the pre and post test answers. We calculated the percentage of answers for each category and the average for all questions, before and after the implementation of the teaching unit, so as to compare treatment effects in both groups and define their reactions to the two methodologies.

**Table 3. Objectives evaluated through the tests.**

Topic/Concept	Objective	Question
Transportation (Integrated Knowledge)	Brainstorming on the advantages and disadvantages of using the different modes of transportation.	1.1
Environmental Preservation (Integrated Knowledge)	Taking on the role of a judicious and engaged citizen. Propose and justify solutions for solving environmental problems.	1.2
Pedestrians' safety in public roads (Problem-solving)	Solving everyday problems related to citizenship and road safety.	2
Average and instant velocity (Physical Sciences)	Distinguish average velocity from instant velocity	3 e 4
Effects of excessive consumption of alcohol in the human body (Natural Sciences and integrated knowledge)	Indicates the effects of alcoholism in the human body.	5.1
	Indicates the average alcohol level tolerated by the human body	5.2
	Relates the laws in effect with the consequences of excessive alcohol consumption on the human body.	5.3
Safety Distance (Physical Sciences and Integrated Knowledge)	Relates safety distance with the several factors that determine alcohol consumption.	6

## 7. Results

Table 4 presents the results from the treatment and control groups in all questions with the exception of question 2. In both groups,

in all questions exceptuating 5.3.2, the results evolved successfully.

This evolution was, as expected, more considerable in the treatment group than in the control group, granted however that the former had a better starting point with regards to all categories in the questionnaire. In the control group, the reduction of the average percentage of "answers not scientifically accepted" was more pronounced from the pre to the post-testing. Progress was superior in all parameters (integrated knowledge, contents of Physical or Natural Sciences, problem-solving) in the treatment group.

**Table 4. Average Percentage of answers to the questions in the questionnaire**

Categories of Answers	Pre-test		Post-test	
	Treat ment	Con trol	Treat ment	Con trol
	% of replies		% of replies	
Scientifically accepted	36	28	63	47
Incomplete	23	26	19	23
Not scientifically accepted	17	27	9	15
Not applicable	5	5	4	14
No reply	23	9	8	8

Another aspect that was taken into account was the qualitative nature of the answers. In question 1, for instance, while in both groups in the pre-test the questions (the correct ones) were centred only on issues related to "speed", "comfort and schedules", in the post-test, the treatment group in particular, brought forth more questions related to "environmental preservation" and "road safety". In question 2- not illustrated in table 4-, which addressed the assessment of competencies in problem-solving, the treatment group clearly reached much higher levels in the post-test. Some students reached the point of conclusive reasoning, while both groups in the pre-test had been limited to the level of prediction and identification of sources of research. This was the most visible accomplishment of the experiment. Nevertheless, the results obtained in the control group were also quite satisfactory.

According to the teachers involved in the experiment and considering the journal of the

class, the control group was inevitably also somewhat exposed to the type of discussions engaged in by the treatment group. Both teachers could not limit the scope of some of the discussions given their relevance to the students' everyday lives.

## **8. Conclusions**

Concerning the proposed objectives, we can conclude that the integrated approach was successfully implemented. The best results were achieved in the integrated approach compared to the disciplinary approach with regards to the development of competencies in integrating knowledge and problem solving.

## **9. Policy Implications**

In light of the results presented in this study, we would recommend an integrated teaching of Science as proposed by the current Curricular Orientations [5]. One such vehicle of integration can be teaching based on problem-solving, given its impact on the development of competencies that are indispensable to deal with the challenges faced by citizens today as agents in a technological society. Education and inter-disciplinary understanding are therefore the pillars of progress for all.

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