

Biology in the secondary school : from the students' views to the school curriculum

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SUMMARY

All scientific knowledge, as its technological applications, is reflected in everyday life. It is urgent that in the present democratic societies, the young act as informed citizens and that some of them decide to follow a career in the scientific-technological area in order to continue social development. To achieve this, it is necessary to stimulate students' interest in the learning of science. Although Biology is in its golden years, little is known about its teaching based on students' views and its compliance with recent international orientations. This empirical study aims to investigate: students' interest in the learning of Biology at secondary level; its origins, how students see the role of practical work in their Biology literacy; how the Portuguese secondary Biology curriculum is organized in order to support and adequate biology education. The sample involved in data collection consisted of 1590 secondary school students from 30 schools. Results allow us to conclude that students show a high level of interest in Biology (themes, practical activities), a finding which is strongly related both to formal and non-formal teaching. Documental analysis carried out on the school Biology programmes shows a lack of relevant themes in the curriculum.

KEY-WORDS: students' interest; Biology school curriculum; STS Biology education.

RESUME

Toute connaissance scientifique ainsi que ses applications technologiques, se réfléchissent dans la vie de chaque jour. C'est urgent que dans les sociétés démocratiques actuelles les jeunes agissent comme des citoyens informés et que quelques uns décident de poursuivre une carrière dans le domaine scientifique-technologique dans le but de continuer le développement social. Pour y arriver il faut stimuler l'intérêt des élèves pour l'apprentissage des sciences. Bien que la Biologie se trouve dans ses années d'or, on sait très peu sur son enseignement en conformité avec le point de vue des élèves et son adhésion aux plus récentes orientations internationales. Cette étude empirique cherche à connaître: l'intérêt des élèves pour l'apprentissage de la Biologie dans l'Enseignement Secondaire; ses origines; comment les élèves envisagent-ils le rôle du travail pratique dans leur littératie de la Biologie; comment le curriculum portugais de la Biologie (Enseignement Secondaire) est organisé de façon à soutenir une éducation en biologie adéquate. L'échantillon a recouvert un ensemble de données de 1590 élèves de 30 écoles secondaires. Les résultats nous mènent à conclure que les élèves révèlent un intérêt de haut niveau pour la Biologie (thèmes, activités pratiques), constatation qui se rapporte fortement soit à l'enseignement formel soit au non-formel. Une analyse documentaire menée au bout dans l'école sur les programmes de Biologie montre l'absence de thèmes importants dans le curriculum.

MOTS-CLES: intérêt des élèves; enseignement secondaire de Biologie; éducation STS en Biologie.

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INTRODUCTION

Throughout the world, but especially in the West, we are going through a period of reflection on the teaching/learning of the sciences for, in order to maintain a healthy democracy, we must educate citizens with a solid understanding of the most important scientific ideas. Citizens who are scientifically literate.

As the understanding of science is something that is constructed throughout one's life, all situations of formal, non-formal and informal learning with which one comes into contact contribute towards it. Despite the fact that these three avenues of access to knowledge are complementary and not substitutable amongst themselves, school continues to be the privileged place for the structured learning of many of the concepts of the sciences, the majority of which are counter-intuitive.

The results of some studies have come to confirm the importance of dealing with socio-scientific subjects and issues at school, as while the social responsibility of citizens and scientists is being concretely discussed, the motivation and reflection brought about in this way leads to a better understanding of the role of science in society, a deeper understanding of scientific knowledge and the development of the capacity for problem-solving (Lock, 1996; Lewis and Wood-Robinson, 1997; Qualter, 1993; Hong et al, 1998). The present tendency is therefore, to redirect the programmes to Science-Technology-Society (STS) contexts.

The STS approach to the teaching of sciences is based on the selection of socio-technological themes that make the learning of scientific concepts relevant and meaningful and develops the curiosity and interest of the pupils.

Another way of motivating the pupils to learn while developing positive attitudes towards science and increasing their interest in it, is through laboratory work (Reiss, 1998).

RESEARCH MATTERS

In Portugal, little is known about the impact of program contents of Sciences and Biology Teaching in particular, in the students' interests. We even ignore if the design of any programmes took into consideration the interests of the people for whom they were intended. Moreover, there is a curricular revision under way at the moment which makes the following questions more pertinent:

1. How do the students' interests evolve during secondary schooling?
2. What is the interest of secondary school students in socio-scientific themes related with Biology and how is this manifest in the school curriculum?
3. What are the expectations of students who opt for Biology Laboratory Techniques¹ as a discipline and what type of activities do the school text-books of this subject propose?
4. What alterations must be introduced in the Portuguese secondary Biology programmes in order to comply with international recommendations?

¹ A discipline with a laboratory bias that is made up of three independent annual blocks - I, II e III - presented as a possible option for students on Natural Sciences Courses.

The assessment of students' interests will have an empirical study as its basis, while the analysis of the programmes and the school text-books will be document-based.

BIOLOGY AND THE STUDENTS' INTERESTS

Methodology

The target population of this study is made up the total number of students of the General Course, in the Natural Sciences area of the public Secondary Schools, of the Aveiro District in the 1997/98 School year, who attended the following subjects: Técnicas Laboratoriais de Biologia Bloco I – TLB I-*(Biology Laboratory Techniques block I - 10th grade)*, of Ciências da Terra e da Vida – CTV- *(Earth and Life Sciences² -10th grade)* and Biologia *(Biology - 12th grade)*.

The choice of Aveiro District was due to the fact that it was of easy access, close to the University and contained a variety of contrasting socio-cultural characteristics. On examining the school network of the District we found that there were 30 secondary schools and we choose to follow an intentional sampling and select one class, per discipline and per school. As the groups of individuals formed in this manner presented distinctive characteristics, we constituted three sub-samples of the main sample.

We used the written questionnaire as an instrument to gather the data; one for each sub-sample (Dias, 1999; Silva, 1999).

The gathering of the data started in October 1997 and we registered a 90% response. The questionnaires we received were analysed one by one and we excluded all those which did not comply with the previously established criteria for completion. The final sampling was made up of 1590 informants distributed in the following way: Earth and Life Sciences - 483, Biology Laboratory Techniques - 579, Biology - 528.

Results

The students' interest in Biology and subjacent reasons

The results of our study evinced that the majority of the students (94%) in the beginning of secondary school (10th grade) attending CTV declared to have a high level of interest in this area; an interest that was maintained for the majority of the students (95%) in the last year of secondary school (12th grade) attending biology. Experiences both inside and outside the school contributed to this high level of interest. In fact, most of the students in both grades indicated the following as principal reasons for this high level of interest: the formal teaching, through the *themes dealt with in class and the experiments carried out*, and non-formal teaching through the *television programmes on living beings and the environment, news and books they have read and the Zoological Gardens, Natural Parks and Aquariums they have visited and also the care for animals*.

² A compulsory subject for all the students who are taking 10th and 11th grades in Natural Sciences Courses.

The importance that the Students attribute to the learning of Biology

The majority of the students in our sample conducted their choice of subjects in the Secondary School in accordance with the interest that these may have in their future professions.

Almost all the professions mentioned by the students, both in the 10th and the 11th grades, were related with the sciences and among these, especially in the 12th grade, the ones that were explicitly related with Biology appeared with a greater percentage expression. The increase that we find in the 12th grade supports the conclusion given above as, at this level, the choice of Biology is optional.

Nevertheless, for the majority of the students attending Biology in the 10th and 11th grades (the subject of CTV) is not seen as a necessity for a future profession alone, or as an unnecessary imposition on their study programs, but as an area of great interest and importance. This position is maintained by the students who, after attending this discipline for two years, opt for Biology in the 12th grade. Supporting this perspective we have the fact that, irrespective of their professional preferences:

⇒ Almost the total number of students in both years considered the learning of Biology in the 10th and 11th grades important (99%), because *it contributes towards the enrichment of their scientific literacy* and because *it is an area in which discoveries are constantly being effected*.

⇒ Many of the students said they opted for Laboratory Techniques in Biology in the 10th grade because of the lower level of difficulty of this subject, or because of their interest, or in order to obtain better marks, but above all, because of its practical laboratory nature and because of the interest that the Biology themes hold in themselves.

Themes that students would like to have discussion on in class

From a list of almost fifty different themes, the students in our sample showed a lot of interest for those related with the human body (*AIDS; Cardiovascular diseases; Nutrition and diets*) or with facts that have implications for human life (*The effects of air, water and soil pollution on life; Climate alterations and life on Earth, etc.*). They were also interested in dealing with themes related with Biology Lab Techniques (*Cell observation techniques; Microscopy techniques*).

With regard to the themes that received a *of little interest* response or were unknown by the students in both years, there are two cases we would like to point out:

1. Although Photosynthesis and Plant reproduction belong to the programmes and the students remember having discussed these themes in their junior secondary school³ and later in CTV, the response of little interest did not change, which may be due to the type of approach, which does not make these themes relevant to the students;

2. Lack of knowledge of the themes like *The use of hormones in plant and animal development, Transgenic plants and animals, Genetic therapy* and *The human genome project* which continues after the students have attended the 10th and 11th grades. If these themes were

³ Our study included the 7th, 8th and 9th grades of compulsory education for students of ages 12 to 15 years.

dealt with in formal teaching, which they are not at present, they may become relevant to the students, as was the case with hereditariness.

Students' expectations with regard to a discipline with a practical laboratory nature

The motivation to learn Biology does not only depend on the interests that the students bring to school. It can also be the result of certain learning situations, among which we find laboratory work⁴ (Freedman, 1997).

In Portugal, at Secondary School students who have choose the Natural Sciences area to proceed their studies, can also choose Biology Lab Techniques, as an option. So, in our study we ask them to indicate the reasons that were most important in their choice. According to the students themselves, it has little to do with questions of less difficulty, or the possibility of getting higher marks. They reiterated the idea that what is important is the practical laboratory nature of the subject, the greater freedom that it allows in exchanging views with all those involved and in the handling of materials and, of course, the interest that the Biology themes have in themselves.

With regard to the teaching/learning methods, the informants declared a preference for the classes in which the students carried out experiments, in groups, following precise instructions given in the school text-book or by the teacher (93%). The classes that were less enjoyed by the informants (only 25% of the students prefer these) are of the demonstrative type, whether the demonstrations are carried out by the teacher or by a group of students. With regard to classes that involve bibliographic research, for the preparation of activities, less than a half (44%) are interested in them.

THE REVISION OF THE PORTUGUESE BIOLOGY PROGRAMMES FOR SECONDARY SCHOOLING AND CURRENT INTERNATIONAL ORIENTATIONS

As from the 80s, it started becoming clear that with the exponential growth of knowledge in the Life Sciences, it was not possible to deal with all the new areas at the junior and higher secondary school levels. There was an awareness that it had become necessary to return to the notion that it is possible to define a small set of fundamental contents in the Life Sciences.

Various proposals of essential contents, that should be included in the creation of future Biology curricula, have been developed, having as their basis a set of previously established criteria (AAAS, 1993; NRC, 1996): *National Research Council (NRC)*; *American Association for*

⁴ Laboratory work is considered here in its broader sense, as all types of activity performed in the laboratory, and not only the carrying out of experiments.

the Advancement of science (AAAS); *Biological Sciences Curriculum Study* (BSCS) and the *National Science Teacher Association* (NSTA).

As the Portuguese secondary school Biology programmes are presently being revised, the first step must be to analyse if they take in consideration the interests of the student and prevalent international orientations, so that, subsequently, decisions on what alterations to introduce can be taken. Hence, the above-mentioned proposals served as a basis for the construction and subsequent use of an instrument that allowed us to analyse, in a systematic manner, the Biology programmes of Portuguese secondary education. Accordingly, we defined six unifying themes and specified the contents that each comprises, through illustrative examples, in a traditional perspective and in the STS perspective: 1. *Origins of life, evolution and biodiversity*; 2. *Cell structure and functioning*; 3. *Heredity and reproduction*; 4. *Development, growth and reproduction*; 5. *Homeostasis of living systems* and 6. *The dynamics of ecosystems*.

The results from the application of the analysis instrument to the Portuguese Biology programmes of Secondary Education, evinced that the majority of the unifying themes are represented in those programmes through the contents proposed there. There are, however, some imbalances that need to be addressed:

1. the list of contents that are necessary for the different themes continues to be extensive;
2. the vast majority of the contents are dealt with in the traditional fashion, moreover, the ultimate aim is the learning of the contents in themselves and not the learning of the contents with a view to understanding real situations. In other words, the relationship science-technology-society is still rather incipient in these programmes.

THE ANALYSIS OF LABORATORY WORK SHEETS

At that point of our study, research into some of the practices in the classroom seemed of interest. Because teachers use very often the school text-book to prepare their lessons, we settled for the analysis of labwork sheets given in those books. For this effect, we adapted a checklist constructed and used by Leach with the “Labwork in Science Education in Europe” project, 1996-98.

The results we obtained show that only five of the twenty four labwork sheets analysed solicited bibliographic consultation and only two implied the planning of a research. The remainder were activities that allowed the students little more latitude than the freedom to interpret data. All the proposals we analysed involved the obtaining of real data generated in the laboratory and only one of them resorted to computer use for the gathering and treatment of the data. We also found that the more frequently proposed activities were of the traditional type, that is, activities in which the students carry out experiments with recourse to the customary laboratory materials, without the use of new technologies and generally following instructions from the worksheets.

CONCLUSIONS

After having carried out our analysis we arrived at the following conclusions with regards to suggestions for future Biology programmes:

⇒ Reduce the amount of specific contents and increase STS themes in order to give meaning to the learning process, specially those relate themes which to the human body and the environment.

⇒ Discuss some themes which are considered of low interest, in STS perspective - Photosynthesis does not generate interest in students, probably because the teaching approach is too related with the mechanism in stead of it being contextualized within problems of social impact, like the contribution of trees in the reduction of the greenhouse effect.

⇒ Increase the use of non-formal means of education in school to bring it closer to society (magazines, newspapers, TV).

⇒ Consider labwork as one of the activities that must be used to teach Biology and remember that it is essential to diversify the types of activities proposed. Special attention must be given to the advantages of making use of computer assisted laboratory work (the use of sensors, interfaces and software for the collection and treatment of data). The carrying out of research work, in response to problem situations, must also be considered as a type of activity that assure the connection between concept and process knowledge.

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