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"Comics" as a tool for teaching biotechnology in primary schools

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More and more, the biotechnology will be important in everybody's life. People will have to be informed and educated on this subject in order to take more conscious and informed choices. Formal and informal education and information programs in biotechnology are already a pressing need to serve a high variable number of beneficiaries as farmers associations, the agribusiness sector, governmental and non-governmental institutions, consumers and the general public, the media, policy makers, non-biotechnology academics, religious organizations and students, including primary schools children. Within this context and as a key element, the children - who will make the decisions and choose the technologies to be used in the future - has to be prioritized in any program of biotechnology education.

Today, the children, not differently of what has been happening with adults, hear a lot about biotechnology, genetically modified organisms and transgenic plants per se without pedagogic oriented and science appropriated explanations. In general they don't have access to education radio or TV programs suited for their level of understanding and learning, fact that produces some confusion associated to, as in the case of Brazil, a negative perception or even rejection about the biotechnology or its use related to food, health and environment. Very probably, due to this lack of knowledge and information, this confusion is perpetuated.

Frequently, the adults in charge of the children education have some difficulties in explaining to the children all these concepts or also don't understand very well the subject. Once out of school, there are few opportunities for adults who do not work in the scientific field to learn about biotechnology, that in general is unknown and uses a language a bit complicated for not experienced people.

In this setting, the school and the teacher - in their role as educators - should play a fundamental part.

Science teachers have a crucial role in increasing the understanding of new scientific technologies and this understanding is the key to achieving benefits for the world's food supply and the environment. They have the responsibility to inform their students in a sound way of the scientific and technical aspects of thebiotechnology and to qualify them as the decision makers of the future to deal in a reasoned way with the chances and the risks of the biotechnology (Harms, 2002). However, it can be observed that, sometimes, even the teachers have difficulty in explaining satisfactorily some of the new technologies, mainly in the specific case of the agribiotechnology.

As the modern biotechnology is a relatively new field of the science that moves forward very quickly, it is difficult for the biology teachers maintain themselves updated with the new techniques, and to incorporate the concepts of the new biotechnology in the education programs in biological sciences. The teachers, frequently, don't have the opportunity to update their knowledge on the subject, in a way they could have more tools for the students' formation, as well as how to present these information in the best way. This situation leads to science classes that often fail to provide even the most basic concepts of biotechnology.

Primary schools teachers have limited access to material suitable for the biotechnology teaching, mainly in Portuguese and Spanish. There are only a few traditional sources of information and a scarce bibliography dedicated to the education in biotechnology. The present textbooks of biology don't include information about the newest developments on DNA recombinant technology and about biotechnology in general. On this, it is fundamental the updating of the education programs in biological sciences and the incorporation of the concepts of the modern biotechnology. The departments of education should update their science curriculum standards with relevant biotechnology material in order to really integrate the

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biotechnology to the teaching, mainly at the school primary level.

In Europe, for example, the topic "Biotechnology" have been integrated into the school curricula in several countries and besides that it has been developed the EIBE (European Initiative for Biotechnology Education) project aiming to inform the public - and the school students in particular - on biotechnology (Harms, 2002). Only when the relevance of the science is highlighted and the biotechnology is part of the education programs of a community, it can be perceived as a tool, something incorporated in everybody's life.

THE REDBIO/FAO NETWORK - A LONG RUN INITIATIVE IN BIOTECHNOLOGY CO-OPERATION

REDBIO/FAO is a technical horizontal network, sponsored by FAO since 1991, that carries out multiple co-operation activities in matters related to plant biotechnology. There are 643 REDBIO's laboratories members in 32 countries of the Latin America and the Caribbean (LAC) with 2349 research and academic graduates and 1542 postgraduates. Its members have shared the task to accomplish REDBIO's objectives in considering biotechnology as a key issue for the sustainable use of regional genetic resources, promoting the safe and responsible application of biotechnology, specially in fragile environments and in countries with low incomes; enhancing the regional development of new strategic technologies, such as molecular genomics, and encouraging the applications, whenever feasible, of advanced biotechnologies in crop integrated management and sustainable production systems. The REDBIO´s guiding principle is to integrate the vision of biotechnology as a tool for sustainable development within proper biosecurity mechanism and Intellectual Property Rights (IPR) framework able to regulate and promote the access to biotechnology, to be focused on the impact of abiotic and biotic stresses which has resulted in low agricultural productivity. Considering that the LAC countries' status in biotechnology and biosafety is at variable degree of development, that the region has conducted 20% of the world's transgenic field trials on 24 different food crops with effective biosafety regulatory frameworks, mainly at Argentina, Brazil, Cuba and Mexico, and the vast range of governmental institutions involved at the regulation of biotechnology there is an stressing need to harmonize focus and role to provide technical assistance.

In LAC, the public sector is largely responsible for 80% Research And Development investment in biotechnology. Within this context, REDBIO/FAO have identified that there is a need to assist in i) developing public perception-education on biology and biotechnology in general, ii) harmonization of biosecurity frameworks with stakeholders with diverse environment, and iii) facilitating access to proprietary technologies combining the intellectual property issues that have thus far proven manageable for most countries.

Considering that the regulatory issues related to biosafety (high regulatory costs, increased public concerns, and lack of knowledge regarding the potential benefits and risks of biotechnology) have confined research products to the laboratory, in spite of research institutes' eagerness to get new products to the farmer and establish evidence of biotechnology's potential impacts on food security among countries in the LAC region, public perception and education/information on appropriated biotechnologies is a high ranked priority. REDBIO has had a number of on-going regional projects, including Research And Development, biosecurity, IPRs, public perception and education, international framework, data banks labs and protocols, infoREDBIO, perciREDBIO and distance learning.

THE PERCI-REDBIO PROJECT - AN INITIATIVE IN BIOTECHNOLOGY EDUCATION FOR LATIN AMERICAN COUNTRIES

Based on the success of the REDBIO Network, FAO is supporting a further institutional development, the REDBIO Foundation. Among the priorities of the Foundation are the need to improve information and the public's perception of agricultural biotechnology, as well to foment the education from people to different levels, in relation to the biotechnology. Aiming to reach this objective it has been designed the Perci-REDBIO project in order to promote public awareness and education on agribiotechnology through the development and dissemination of "public perception" modules. A first working module “course” was aimed to promote education on agribiotechnology in primary and secondary education, providing programs and didactic materials introducing professors and students to the scientific basis of molecular biology and recombinant DNA.

THE COURSE "AGRIBIOTECHNOLOGY IN THE SCHOOL"

The Course Agribiotechnology in the School comprises materials designed to educate students of the primary level, ages 12 to 14, in plant biotechnology. The course was designed, under the framework of the REDBIO Network and the REDBIO International Foundation, by a group of professors and presented, in a first stage, to 30 primary schools of Rio Grande do Sul State/Brazil, to an approximate number of 3000 students. It was translated to Spanish to be presented to the Ministries of Education of Argentina, Chile, Peru and Uruguay, in order to be implemented in the region.

The project focus was to design a course keeping in mind that education can be considered as the construction of the knowledge in constant mutation, a sum of: a) academic knowledge - information; b) cultural knowledge - the knowledge that puts the academic information in a context; and c) knowledge for simulation - fiction (Biasoli, 1999).

Based on these premises, the present day information on biotechnology was contextualized within a fiction storyboard as part of the course design. The fiction, very close to the imaginary juvenile thinking, is considered as a metaphorical form of knowing the world, stimulating the understanding of concepts, the creation and the imagination.

As in any science education program, the information presented as something rigid, without innovations, become a "bale". However, if this information is diluted in the adventure, in the humor, it is received with excitement and the learning process doesn't have barriers or restrictions. Considering that, for the design of the course Agribiotechnology in the School, it was chosen the comics - words and illustrations combined - as pedagogic tool.

COMICS AS A PEDAGOGIC TOOL

Comics are pictorial images and graphics juxtaposed in a deliberate sequence destined to transmit information and/or to produce an answer in the reader. They have more than 100 years of existence, and were always used with success as an instrument of dissemination of ideas and of public utility in several types of campaigns. The comics have the particularity of combining two very rich forms of cultural expression: the literature and the plastic arts, what makes them a very effective pedagogic tool. When completely explored, words and illustrations have an enormous power to tell stories and to transmit messages (MacCloud, 1993).

When we used comics as a way to present scientific information, we are showing and teaching scientific concepts through the channel of the adventure. The information, that usually would be rigid, becomes agile, through illustrations and events that are familiar to the imaginary of the children (fantastical trips, difficulties imposed to the heroes...).

One of the most interesting characteristics of the comics is the fact that the readers can deduce the meaning of the history, even if they have not yet read it directly. Images are received information. Nobody needs formal education to understand the message. It is almost instantaneous. In addition, another characteristic very peculiar to the comics is the fact that the space between the pictures is where the reader imagination captures two different images and transforms them in a single idea. The conclusion allows to connect the moments and to conclude mentally a continuous and unified reality. Each action registered in the paper by the designer is aided and supported for a "silent" accomplice, the reader. The readers participate, they use the imagination to "fill out" the spaces among the pictures, becoming, this way, active participants of the history (MacCloud, 1993). And the participation is a powerful force in any mean of communication, mainly when the target are children, that have a lively imagination and are not interested in rigid and static concepts. Biotechnology is not rigid and static, it is dynamic. Therefore, teaching it by the use of dynamic tools seems to be a very reasonable way.

In the course Agribiotechnology in the School, the visual narrative served as an instrument of pedagogic mediation, so that the students became not only critical appreciators of the reading, but also agents and builders of knowledge. The use of the comics, besides sending to situations of the student's daily life and of the social life, makes possible the reflection on the proposed theme, the confrontation of ideas, the search for solutions and alternatives and the autonomy in the learning. As didactic instrument, the comics, besides working with different situations proposed by the narrative and with different images composed of characters, can involve the student in other areas of knowledge.

CONTENTS OF THE COURSE

The course Agribiotechnology in the School presents a didactic unconventional material visually attractive, containing information on plant biotechnology and setting the study of the plant biology in a real and current context. It consists of a comic divided in five chapters and a guide for the teacher. The Teachers Guide explains the project, its objectives, the reasons why it was chosen comics as a pedagogic tool, and all the theoretical content developed in the story. Besides presenting in a more detailed way the concepts shown in the comics, with explanatory drawings, additional information is supplied, such as curiosities and some historical data, to enrich the work in classroom. One of the objectives of the guide is to facilitate the teachers' work in a way they don't need to look for additional materials. In the same way, in the end of the guide, are presented some suggestions of fixation and evaluation activities.

In the comics, the basic concepts of the agribiotechnology were inserted in an adventure: "Journey to the Center of the Leaf". The children are introduced to the concepts of biotechnology, DNA recombinant technology, genetic improvement and domestication of plants, gene and gene expression, among others, as well to the understanding of basic principles of genetic engineering and genetically modified plants. Questions regarding how and why genetically modified plants were developed, and the importance of the risk management and biosafety are included.

The main characters of the comics are a scientist - Genésio; a girl - Nina; and a dog, Nilo (Figure 1). As Nilo is a lazy student that is not doing well in Sciences, Nina, his friend, introduces him to Genésio in order the scientist helps him to understand what are genes, DNA, genetically modified plants, among other subjects related to agribiotechnology. Genésio takes them in a spaceship to a journey to the center of a plant leaf, but the spaceship falls down and they don't know how to get out of the leaf cell. While the readers

Figure 1. Genésio, Nina and Nilo, the characters of the adventure "Journey to the Center of the Leaf" in the course Agribiotechnology in the School.

accompany the adventure, they can learn several agribiotechnology concepts.

The adventure is divided in five chapters. In the first one, the students get in contact with the biotechnology, becoming aware that the traditional biotechnology was already used by the man thousands of years ago, in processes such as the fermentation and the breeding of plants. In the second chapter, the students review the concepts of DNA, genes, RNA, among others, and can understand how the genetic language works and what are genetic modifications. In the third chapter, it's shown the need for a more productive and sustainable agriculture, using less pesticides, as well the way the genetically modified plants can help to solve some of the problems faced by the farmers. The students can understand too how the biotechnology can complement the traditional plant breeding. The fourth chapter shows the necessary steps to be followed in order to develop a genetically modified plant, and the techniques more used for doing that. And, finally, in the fifth chapter, the readers can know which genetically modified plants already were developed, and have notions of biosafety.

This material was also adapted for presentation in CD-ROM and for incorporation to the Web-Site of the REDBIO Foundation, being included some effects of animation and sound. The printed materials and/or CD-ROM of the course are available under request to the International REDBIO Foundation, ZONAMERICA Business and Technology Park, Ruta 8 Km 17,500., Local 208 B.C., Of. 3, Montevideo, Uruguay, e-mail: redbio-st@adinet.com.uy.

CONCLUDING REMARKS

The association between fiction and comics stimulated the students' imagination - the presupposition of the creation processes that impel the children's potential. The teachers in general considered the use of science fiction and comics as a very effective tool for teaching biotechnology. As the fiction makes part of the world of the children, they assimilated easily, and even almost "playing", the concepts of agribiotechnology presented in the comics, showing great curiosity on the topic, asking many questions and being motivated to look for more information in magazines, newspapers, internet and other means.

The use of science fiction, contextualized and identified, strengthened the understanding and construction of the scientific contents, with a ludic and playful vision. The children showed a perfect understanding of the proposed theme and an appropriate discernment to separate the scientific reality of the science fiction. The science fiction worked as an incentive. It was the insertion of the dream, the ludic and the pleasure of reading and learning.

In spite of the topic biotechnology of plants not being yet part of the schools program of primary level in Rio Grande do Sul/Brazil, the teachers have been proactive and willing to use the course material because they considered very important that the children knew more about this matter considered still polemic in the country. Many of them carried out extra activities, such as drawings, theatrical presentations, "creation" of new genetically modified plants. Regarding to the evaluation of how much the children have learned about agribiotechnology, the teachers have asked them orally a set of questions proposed in the end of the Teacher's Guide, and most of the children guessed right all the answers.

In fact, it has been demonstrated that the objectives of the course are being reached: the children that have already used the material know what is agribiotechnology and understand the importance, potential and limitations of this important tool that can be used to fight the hunger and promote the development.

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