Outreach Project in a Brazilian High School to Improve Critical Thinking

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Abstract

This paper was written to share a Brazilian research in the field of Science Education. It has been done with teenagers at the ages of fifteen and sixteen in a private school. In the beginning of the year, pupils have been invited to attend a one year extracurricular project in the field of Biotechnology. This project was implemented to achieve one main goal: become an educational tool to improve critical thinking and interest in developing a scientific research in teenagers. Attending this project, teenagers have the opportunity to (1) engage in some contemporary issues in Biotechnology and Bioethics, (2) manipulate lab materials, (3) develop a number of important skills in order to enhance their capability in teamwork and communication, and (4) get information related to Social Entrepreneurship. Data suggests that Biotechnology Project can be considered an important tool to promote motivation in developing a scientific research, to improve critical thinking and to increase ethical concerns in High School.

1. Introduction

Bioethics and Biotechnology in contemporary Biology programs are important issues to be considered in Science Education [1][3]. Any Science Education (SE) program should highlight the relevance of the subject reported in the news media, showing the importance of a good grasp of Biology and Ethics to the population in general [1][3]. From a pedagogical and a didactical point of view school education must deal with the basic knowledge as well as with the possible effects of Biotechnology. In addition its aim should be to improve the students' ability of rational decision making in respect to this technological field [1]. One of the most common issues in SE is how to motivate students and arouse interest towards science learning [6]. Despite world-wide attempts of SE, science educators are still concerned about the decline of students' interest and lack of relevance in SE and towards school science. It is thus appropriate to establish pertinent and interesting ways to motivate science learning at school [6]. In order to develop an applicable policy of SE at school, some important goals have to be considered as a possible answer to the question "*What should all students know and be able to do?*" 1. share information; 2 .deal with technology; 3. be well informed/updated; 4. have team spirit; 5. have critical thinking; 6. be self-organized [5].

Another fairly recent document that emphasizes goals of Education is the Melbourne Declaration on Educational Goals for Young Australians which especially sees successful learners as students who are motivated to reach their true potential [5]. A number of individuals and programs have demonstrated the potential for catalyzing widespread improvements in science education by building and nurturing appropriate partners [2]. This article is related to an interdisciplinary project called Biotechnology Project, implemented with teenagers in a Brazilian private school. This subject is considered complex to be taught in High School because this field of Science has to be worked in an interdisciplinary way including hands-on learning. Ethical and social aspects should be taken into account to give the students the opportunity to improve their critical view. They have to know the main methods being implemented and used in biotechnology procedures and they must learn to judge in a rational way the ambivalent application possibilities of these techniques.

Colégio Bandeirantes is a private school which has been amassing impressive resources to wire and equip teachers and students with powerful interactive technologies and educational projects to motivate teaching and learning processes. The school has been working with a one-year educational project called Biotechnology Project since 1998.

Figure 1. Lecture with an expert.

Attending this project, teenagers have the opportunity to (1) engage in some contemporary issues in biotechnology including bioethics, while at the same time they can (2) manipulate lab materials, (3) develop a number of important skills in order to enhance their capability in teamwork and communication, and (5) get information related to Social Entrepreneurship, one important field of knowledge nowadays in any kind of activity, including a scientific career.

Figure 2. Hands-on learning

Figure 3. Working in groups to solve a problem

Figure 4. Virtual environment to improve learning

2. Objective

This paper aims to present a methodology based on an outreach interdisciplinary project to promote improvements in critical view about Biotechnology achievements nowadays in a group of teenagers. Bioethics and partnerships between teachers and experts are considered essential to achieve this goal.

3. Methodology

During the period of three years (2011-2012-2013), 102 High School students between the ages of 15 and 16 years (38 students from 2011, 29 students from 2012 and 35 students from 2013) attended the program. In each year of the project, with once a week meeting (two and a half hours), students (1) took part in lectures related to different fields of knowledge (Biotechnology, Geography, Bioethics, Social Entrepreneurship and Marketing), (2) attended classes about basic knowledge in Cytology, Genetics, Chemistry and Molecular Biology, (3) visited University laboratories (University of São Paulo) and Research centers, and (4) took part in practical activities organized by experts.

All topics and activities were organized into four modules of work (see Table 1). During these activities, they frequently worked in groups, researching and debating about different issues including bioethics, stem cells, clones, GM food and gene therapy.

Table 1. Brief description of modules developed in Biotechnology Project

MODULE 1	MODULE 2	MODULE 3	MODULE 4
Theoretical classes related to basic	Hands-on learning- DNA extraction	Hands-on learning – PCR (Polymeric	Hands-on learning - Bacterial transforma

knowledge required.	(practical activities).	Chain Reaction) (practical activities).	tion with recombina nt plasmids (practical activities).
Lecture: Biotechnol ogy nowadays-promises and reality.	Theoretical class and research: Methods to produce transgenic organisms.	Synthetic Biology - kits to work in groups.	Oral presentati ons: Final course works.
Lecture: Principles of Bioethics.	Lecture: Political and economic aspects of GMO-an overview.	Hands-on learning: Restriction enzymes and recombina nt plasmids (practical activities).	Final debate with experts about one polemic issue related to Biotech.
		Orientatio ns about final course works.	Project evaluation

In a virtual learning enviroment inside Bandeirantes' Webpage and in a private group inside FACEBOOK, students had all information required to attend the program.

In the end of the project they had to develop a proposal including marketing, social entrepreneurship and scientific knowledge, all based in Bioethics principles, to create one ficticious transgenic product or to solve one important Social /Human health problem researched by them. In addition, students evaluated the project answering a written questionaire composed by open-ended and multiple-choice questions. Qualitative and quantitative methods were used to analyse the data [7].

Data shown in this paper (tables 2 and 3) were collected during the last three years (2011-2012-2013) of Biotechnology Project development, based on an online questionnaire being showed below:

3.1. Biotechnology Project 2013 - Annual evaluation of the project

You participated in the Biotechnology Project and your evaluation is very important for us in order to improve it. Be sincere in your answers and, wherever possible, write important considerations when it is possible.

1. The Biotechnology Project was important to provide training and / or improvement of your critical view on topics related to Biotechnology.

- I don´t know.
- It was not important.
- It was important.
- It was very important.

2. Regarding the acquisition of expertise in Biotechnology, the Project:

- did not add expertise beyond those already acquired in curricular classes .
- added little specific knowledge beyond those already worked on curricular classes .
- added many skills beyond those already worked on curricular classes .
- I believe I can´t evaluate it at the moment.
- Other :

3. All activities carried out in the Biotechnology Project (lectures, group work, practical activities, visit to laboratories) were important to motivate you to go on attending the project throughout the year.

- I do not know.
- It was not important.
- It was important.
- It was very important.

4. The project was important as a stimulus to work in groups and brainstorm ideas.

- I do not know.
- It was not important.
- It was important.
- It was very important.

5. The project's organization was important to provide direct contact with experts from different areas of knowledge.

- I do not know.
- It was not important.
- It was important.
- It was very important.
- Other :

6. Before participating in the project, your interest in developing a scientific research:

- I don´t know.
- Was zero. I had no interest in this - activity.
- Was minimal. I had very little interest in this activity.
- Was reasonable. I have thought a bit about this possibility.
- Was already good. I've wanted to do this.
- Has always been great. I want to be a researcher.

7. After participating in the project, your interest in developing a scientific research:

- I do not know.

- Is inexistent. I have no interest in this activity.
- Is minimal. I have very little interest in this activity.
- Is reasonable. I am thinking a little bit about this possibility.
- Is good. I just want to do this.
- Remains great. I still want to become a researcher.

8. The project was important to facilitate learning specific knowledge based on the contact with researchers.

- I do not know.
- It was not important.
- It was important.
- It was very important.

9. The project was important in order to allow you to experience expert´s routine in the field of Biotechnology through practical activities and visits to research laboratories.

- I do not know.
- It was not important.
- It was important.
- It was very important.

10. The project was important to increase your ethical concerns regarding attitudes and opinions related to genetic material manipulation.

- I do not know.
- It was not important.
- It was important.
- It was very important.

11. Describe some positive and negative points about the project (general organization, dynamics of the meetings, contacted experts for lectures, proposed activities).

12. Regarding to the proposed activities inside the Biotechnology Project, which do you believe are essential / important?

You can choose more than one item.

- Lectures.
- Visits to laboratories.
- Lectures.
- Practical activities.
- Group activities (research, debates, presentations).

13. Select words you would use to describe what Biotechnology field brought to your mind BEFORE taking part in the project:

More than one item can be selected.

- Curiosity.
- Fear.
- Form of power.
- Professional goal.
- Hope to solve problems / needs.
- Something far from their reality.
- Conscious use / need for limits.
- Complexity.
- Other :

14. Select words you would use to describe what the Biotechnology field brings to your mind AFTER taking part in the project:

More than one item can be selected.

- Curiosity.
- Fear.
- Form of power.
- Professional goal.
- Hope for the solution of problems / needs.
- Something far from their reality.
- Conscious use / need for limits.
- Complexity.
- Other :

15. Did you know you would need knowledge about Entrepreneurship within the scientific career before participating in the project?

- No. I knew something about Entrepreneurship but I didn´t know this field was required in a scientific career.
- I already knew the importance of Entrepreneurship in Science, but I didn´t know it could be essential in a scientific career.
- I already knew the importance of Entrepreneurship in Science as well as in a scientific career.
- I already knew Entrepreneurship was very important and essential in a scientific career.
- Before the project, I didn´t have knowledge about Entrepreneurship
- Other:

16. Did you start to believe, after participating in the project, that knowledge about Entrepreneurship within the scientific career is required?

• No. I know what Entrepreneurship is but I don´t see connection between this field and a scientific career.

• I think Entrepreneurship is important but not essential in a scientific career.

• I know that Entrepreneurship is important in scientific career.

•I know that Entrepreneurship is very important and essential in a scientific career

• Other:

17. Do you believe your participation in the Biotechnology Project influenced in your reflection on choosing a career?

- No. It had no influence.
- It influenced a little bit.
- It influenced significantly.
- It strongly influenced.
- Other:

Table 2. Results – 102 questionnaires analyzed

Biotech Project was important to:	I don´t know	It was not important	It was important	It was very important
1. Improve your critical thinking about Biotech themes	0 –	4 (3.9%)	30 (29.4%)	68 (66.7%)
2. Stimulate group work and different ideas.	3 (3%)	6 (5.9%)	59 (57.8%)	34 (33.3%)
3. Promote direct contact with experts from different fields.	3 (3%)	6 (5.9%)	59 (57.8%)	34 (33.3%)
4. Facilitate learning specific topics through getting in touch with experts.	3 (3%)	4 (3.9%)	45 (44.1%)	50 (49%)
5. Experience a researcher's routine through lab activities.	1 (1%)	3 (3%)	34 (33.3%)	64 (62.7%)
6. Increase ethical concerns regarding attitudes and opinions related to the manipulation of genetic material.	3 (3%)	11 (10.7%)	36 (35.3%)	52 (51%)

Table 3. Results – 102 questionnaires analyzed

Your interest in developing a scientific research:	Before taking part in the project	After taking part in the project
I don´t know.	1(0.98%)	1(0.9%)
Was zero. I didn´t want to do this activity.	5 (4.9%)	2 (2%)
Was minimum. I had little interest in this activity.	36 (35.3%)	16 (15.7%)
Was reasonable. I had thought of doing that.	40 (39.2%)	38 (37.3%)
Was significant. I´ve already wanted to do this.	13 (12.7%)	34 (33.3)
It has always been great. I want to be a researcher.	7 (6.92%)	11 (10.8%)

4. Results

Results presented in Table 2 suggest that the Biotechnology Project was considered by most participants as an important or very important tool in all listed topics. It stands out in this table the excellent project evaluation regarding topics 1 and 6, which respectively refer to critical thinking and ethical concerns regarding attitudes and opinions related to the manipulation of genetic material. Data shown in Table 3 highlights a relevant number of students becoming more

s and opinions related to the manipulation of genetic material. It is apparent from this Table that very few participants considered the project not important in all items evaluated in the questionnaire.

The results in Table 3 indicate that the project was considered important to motivate students in developing a scientific research. 35,3% indicated that their interest was minimum before taking part in the project. This percentage decreased to 15,7% after taking part in the project motivated in carrying out scientific research in the future after attending Biotechnology Project.

5. Discussion

As can be seem from the data in Table 2, the Biotechnology Project was evaluated as important (29,4%) and very important (66,7%) to improve critical thinking about Biotech themes, as well as it was considered important (35,3%) and very important (51%) to increase ethical concerns regarding attitude and the amount of students with significant interest increased significantly by comparing data.

One section of the questionnaire required respondents to give testimonials with information about the importance of Bioethics to discuss genetic manipulation. The overall response to this topic was very positive, as can be see in some testimonials transcribed below:

- "I didn't know the importance of Ethics in Science."
  - "…my critical view from the Ethics related to manipulating genetic material increased."
  - "Before the project I´d never have imagined there were so many difficulties, especially in the field of Ethics, being faced in Biotechnology."
  - "We realized that everything, including scientific research, has ethical and developmental limits."
  - "I´d never thought of several questions displayed and discussed during the project."
  - "I started to pay attention to the concerns that should be taken in account when developing any project."
  - "Before the project my ethical views were very different! The programme opened my mind!"

6. Conclusions

Data suggests that Biotechnology Project can be considered an important tool to promote motivation in developing a scientific research, to improve critical thinking and to increase ethical concerns in High School. Students reported significant improvement in their critical thinking about themes related to Biotechnology. On the other hand, taking in account the decline of students' interest and lack of relevance in Science Education, the methodology proposed in this research can be considered useful for anyone interested in developing a Scientific Program in a High School to stimulate students in pursue a scientific career.

7. References

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