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A 12 YEARS BRAZILIAN SPACE EDUCATION ACTIVITY EXPERIENCE

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ABSTRACT

A multidisciplinary group of students from the university and latter also from the high school was formed in 1988 with the objective to make them put in practice their knowledge in physics, chemistry and mathematics and engineering fields in experimental rocketry. The group was called "Grupo de Foguetes Experimentais", GFE.

Since that time more than 150 students passed throw the group and now many of them are in the space arena.

The benefits for students in a space hands-on project are many:

- More interest in their school subjects is gotten as they see an application for them;
- Interrelation attitudes are learned as space projects is a team activity;
- Responsibility is gained as each is responsible for a part of a critical mission project;
- Multidisciplinary and international experience is gotten as these are space project characteristics;
- Learn how to work in a high stress environment as use to be a project launch.

This paper will cover the educational experiences gotten during these years and how some structured groups work. It is explained the objectives and how the group was formed. The group structure and the different phases that at each year the new team passes are described. It is shown the different activities that the group uses to do from scientific seminars, scientific club and international meetings to technical tours and assistance to rocket activities in regional schools.

It is also explained the group outreach activities as some launches were covered by the media in more then 6 articles in newspaper and 7 television news.

In 1999 was formed an official group called NATA, Núcleo de Atividades Aerospaciais within the Universidade Estadual de Londrina, UEL, by some GFE members and teachers from university. It is explained the first group project results.

INTRODUCTION

It is a tendency nowadays to give the educational activities a more practical emphasis. Educators are discovering again that the students learn more quickly and fix the concepts easily if they apply the new knowledge in a practical work. The "case" method is an success example in many renowned business schools. Many medical schools are reorganizing their curriculum in the new molds of the "Problem Basic Learning" method that make the students learn the disciplines discussing disease cases.

In 1988 a group of teachers and graduated students noticed that a practical activity would help the students of the different engineering courses of the Escola Politécnica of the São Paulo University. The activity would have the following objectives:

- Integrate the different engineering courses students into one multidisciplinar engineering project that would make them apply their different knowledge;
- Introduce them in the scientific and technologic research;
- Give them an engineering development team experience;
- Make them use the creativity, the capacity to overcome obstacles in a cooperative ambient.

After some discussing ideas it was found that an group with a project of an experimental rocket that they would project, build, test and launch would fulfill the above objectives. So, it was created what was called the "Grupo de Foguetes Experimentais".

Rocketry was chosen as the applying field for the exact area for some reasons:

- Space Projects are multidisciplinar and would give a global view and make links between the disciplines in one course and between courses;
- Working in a practical project that would be constructed and operated by the students makes them put in practice their background knowledge and fix the concepts;
- Space related projects are usually linked to high technology and challenges. This makes the students feel "special" and makes them motivated to study more the linked disciplines;
- Rockets are critical mission projects. Every system or elements must work properly or will jeopardize the entire rocket.

Also in the engineering point of view rockets are a challenge because the environment is very aggressive: high loads, accelerations, vibrations, and the safety margin can't be great because of the weight.

So, working in an aerospace project makes the students more responsible and cautious. Even if the student will not work in this area, he will carry these virtues to their professional behavior.

HISTORY

In this part it is commented the evolution of the group with a focus on the good experiences taken for the education of the participants.

The group was created at the end of 1988 but began in the middle of 1989. It was chosen 10 students from some engineering courses as electronic, mechanics, robotics, civil and chemical engineering.

Most of them were from the first year and two was in the last year. One of them was José Miraglia that was the only one who had previous experiences in rocketry and soon became one of the directors with Fernando Stancato as the general director of the group.

Between 1989 and 1991 a mean group of 8 students stayed in the group. During the last 1989 semester the group had weekly seminars covering the basics of rocketry.

In 1991 it was projected, built and launched a zinc-sulfur rocket and tested two sugar and sodium nitrate motors that exploded. A static test stand with computer data acquisition was built and used in those static tests.

In order to know the state of the art about rocketry and show what was being done the GFE group organized a two days national seminar on rocketry. Some people came from other states and it was presented 8 topics covering propulsion to materials.

In 1992 the group ended their activities at Escola Politécnica and started again in the same year in the city of Londrina, Paraná.

The activity was organized in two different groups. One group with university students, mainly from the civil engineering course, kept working in the sugar-sodium nitrate ballistics and the development of a motor. A group of high school students was started. They began a project of an experimental rocket less the motor.

Five students from a civil engineering course formed the group from the university. The group spent all the year of 1992 and 1993 studying the internal ballistics of the sugar – sodium nitrate propellant. It was decided to use this propellant because its components are easily obtainable and secure in manipulation. During these years burnrate – internal pressure correlation was calculated and the thermodynamic burning gas properties were found.

In parallel, the high school team (6 students) worked in a series of researches including a timer for parachute deployment, the launch tower and aerodynamic stability. During this period it was done 6 launches with rockets built with clustering of four 20 N.s commercial hobby rockets motors and 15 experimental rocket motor static tests. Dividing the researches in two independent areas proved to be very useful as the participants learned what is an evolutionary approach and the launches kept the motivation as the experimental motor was in development.

In 1994 a small motor of about 250 N.s, M1, was developed with an end burning grain. Two sequences of static test and launch was done and in both occasions the motor worked fine in the static tests but exploded at the launches. It was found that as the throat diameter was very small (1,5 mm) any little particle would close it.

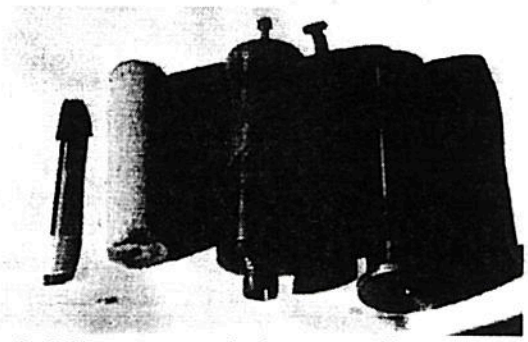

Fig. 1. M1 motor with the propellant grain and its mold.

In 1995 a modification in the motor lead to the first successful flight of a 2,5 Kg, 1.6 meter and 63 mm diameter rocket.

The grain was modified to an unrestricted burning unit, single hollow charge. In this way the throat diameter increased to 10 mm. Two static tests were done and in September of that year it was done a launch. The motor worked well but the rocket motor mount broke and the rocket did some nice loops in the air. In November this problem was fixed. A launch with perfect flight was done but the parachute did not deploy.

Fig. 2. The GFE group in 1994 in the first M1 launch.

In 1996 most of the year was spent in a reliable recovery system project. The earlier system was not redundant and had no special structure for it. The project team decided that was time to spend time and money in a reliable recovery system because the rockets were not exploding anymore and the structure construction and tests were well understood.

It was done an electronic compartment right behind the nose cone that had two independent redundant timers with redundant batteries and redundant pyrotechnic charges. Extensive ground tests were done on the ejection of the parachute.

To avoid future problems with the structure as happened in the last launch the students decided to make tests with it before flight. The structure team developed a way to calculate the forces that act in the structure using what they had just learned in Physics and submitted the rocket structure to these loads in a static way. Nowadays every new rocket has to pass in this static load test before flight.

At the end of the year a launch was done and it was a perfect flight with excellent recovery.

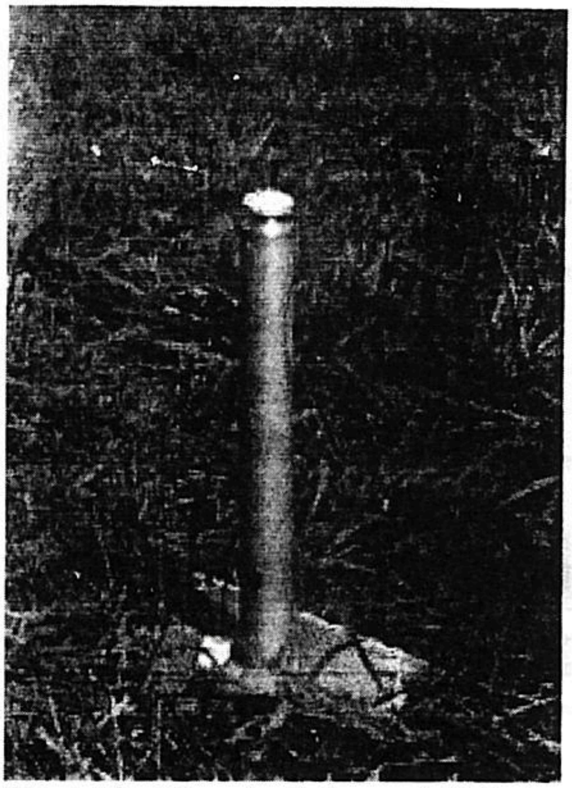

Fig. 3. The M2 motor before a static test.

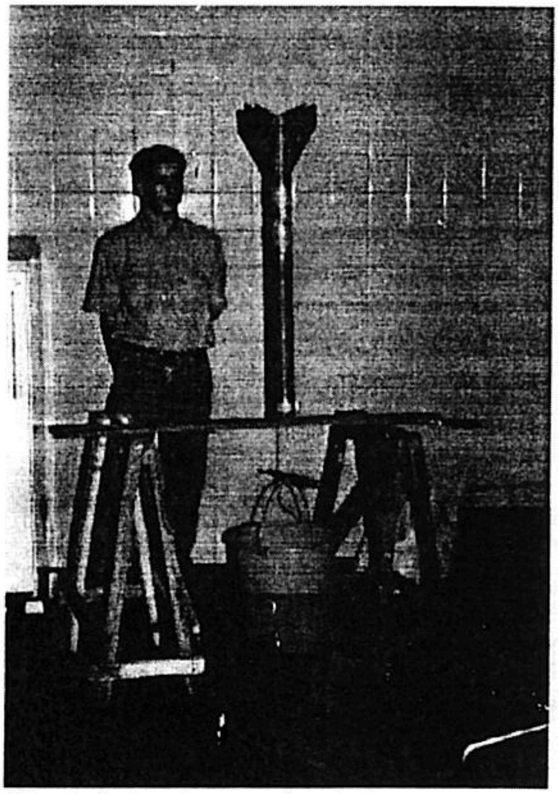

Fig. 4 A structure rocket test.

During the year of 1997 a new motor was developed, the M2. It had 750 N.s of total impulse and had a low combustion pressure design. Another feature was that it was made with composite tube having almost the same weight of its predecessor and 3 more power.

While tests were done with the new motor more 2 successful flights were done.

The first flight had perfect parachute ejection but it landed in a river! The students were getting sense that space projects are critical mission from the ignition until recovery.

After this flight the group began to make before each flight an "event tree". A tree of events is done since the ignition until the last phase. After each phase it is put the consequence of the success or not of that phase. Usually the failure of a phase leads to total destruction of the rocket. Although very simple, this makes the project and the launch team aware of all the possibilities that a failure can cause and makes them propose actions to minimize the effects.

One attitude taken for a subsequent flight was to do a smaller parachute in order not to get the rocket wet or lost!

A flight with the M2 motor was done at the end of the year after 2 static tests. Inside the nose cone was put a commercial accelerometer that logs the acceleration, velocity and the altitude and fires a charge at the apogee and at 150 m of altitude for a two-stage recovery.

The students decided not to use the recovery option just to test the circuitry of the accelerometer and the recovery relayed at the old group's timers. The flight would have been a success if the parachute had not been burned by the pyrotechnic charge.

During the 1998 a two-stage project began. It was decided that both stages had to be recovered by parachutes. The first stage motor was the M2 and the second stage would use the M1 motor.

In the beginning of the year was received an invitation to the group to participate in a festival held by the CNES and the French association ANSTJ of rocket clubs.

The group prepared and launched there the "Brasilis" rocket. It was found this international event very productive for the students experience specially in getting contact with other cultures and exchange

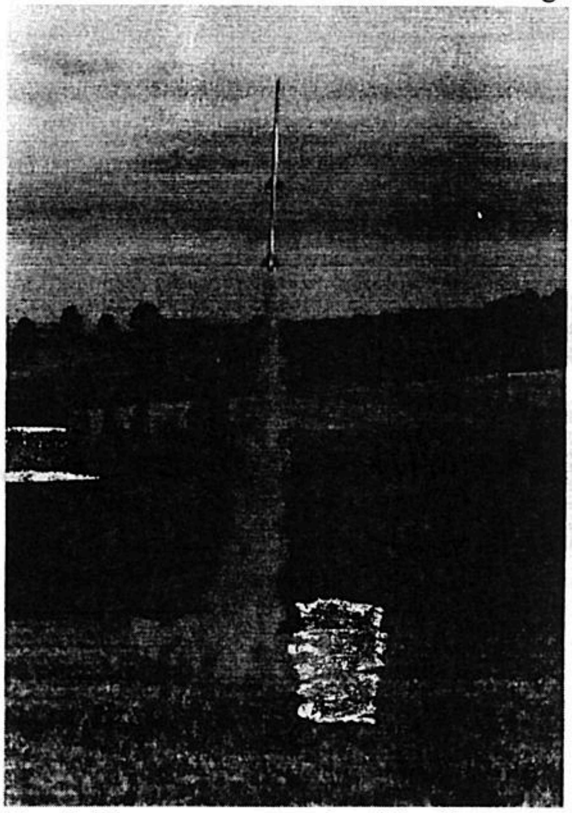

Fig. 5. The two stage rocket lift off.

Fig. 6. GFE in the French launch campaign.

ideas with other students of their age that like the same theme: rockets!

After the French festival we had 2 flights of the second stage. In the first flight the ignition was done over the first stage just to test the separation and the second flight was with the two stages linked but with the 2° stage motor inactive. This evolutionary procedure proved to be a good idea as the interstage broke during the propulsion of the first stage making the rocket do some looping.

Fig.7.An TV interview before a launch.

The year of 1999 can be called the outreach year for the group. It was done 2 launches with the regional TV presence. The group also did a five days course to basic and high school students on rocketry. Meantime the launch of the two-stage rocket was done with success.

The director of the group and one member were chosen as delegates to participate in a parallel event of UNISPACE III held in Vienna. The event was the Space Generation Forum and was an excellent opportunity to put in practice one of the main goals of the group that is to promote intercultural and interdisciplinary activities.

STRUCTURE

Nowadays three different groups form the GFE:

University Group

Undergraduate students, most of them doing engineering courses, form it. Some of them were former high school members and they give a support for the high school group as tutoring. Each undergraduate have their students group and is responsible for directing their specific part of the project and their individual monograph.

Master Group

This group was formed in 1998 by professionals that like rocketry and would like to help the other two groups. They are intended to develop and test new technologies and give support to the high school group. They did their own two-stage successfull recovery rocket with a 3000 N.s motor.

High School Group

This is the main group. They have a one year and half program and at each year a new team begins. They meet once a week for two hours and a half. Each new team has a different project that uses to be an evolution of the previous project. Although the program has a fixed time, the member is free to live the group whenever they want or stay as long he wants, as high school member or undergraduate or graduate member. During this year and a half they will be in contact one semester with the previous team. This six moth contact with the previous team has the following advantages:

- The new team is motivated by a project that is almost done;
- They get the experiences from the last group and the former team learns how to give their informations and experiences;

• Informations and inputs for their project is gotten while they help the previous team in such a way that they see what could be better made. In this way there is always an evolution in the projects and there is no solution of continuity.

While participating in the former team project, the new team begins to do the basic concept of their project:

- Decide what will be the objective;
- Selection of the motor;
- Basic dimensions and characteristics are established.

In this period some classes are done about the principals on each area.

After the principals are understood the project is divided in parts. Each part is assigned to one or two members. They will be responsible for the project, construction and test of the project's part: propulsion, aerodynamic stability, structure, recovery system, trajectory and payload.

The division of the work has some interesting benefits for the participants:

- First, the member feels more responsible for the project. A specific part belongs to him and a failure of it can jeopardize the entire rocket.
- They learn how to work as a team because his part depends on the others parts. The structure loads depends on the aerodynamics analysis, the design of the parachutes depends on structure weight which in turn depends on the parachute opening loads, etc.

Themselves construct some parts as external and internal structure. The motors and the parachutes use to be done by professionals.

Usually, whatever is possible to test on ground is tested: parachutes ejection, streamer drag force measurements, structures static tests, etc.

When everything was tested they do the parts integration as mounting the electronics, parachutes linking...

Fig 7. The integration is one of the last phase project.

Some weeks before the launch it is done the launch logistics. The launch tasks are divided between the members: mount the ignition system and tower, take pictures, rescue team, etc.

A chronology with time, local and each event duration, 24 hours before the launch time is done in order to assure that nothing will be forgotten or skipped.

After the flight some meetings are done to analyze the data and see what was good and what to improve next launch.

OTHER ACTIVITIES

Besides the activities described, some other events are promoted in the scientific – technologic exchange and outreach.

Each member develops a monograph linked to the project that was developed during the normal program time. Usually these papers are presented in a seminar to the teachers that will evaluate the work. In this way the student get used to scientific paper preparation and exposition.

One of these papers is presented each year in a "Young Scientist" Congress held in a very outstanding university here in

Brazil which gathers scientific and technological projects from the best country schools. In two participations, the group got the third place and the "Hors Concours" prize.

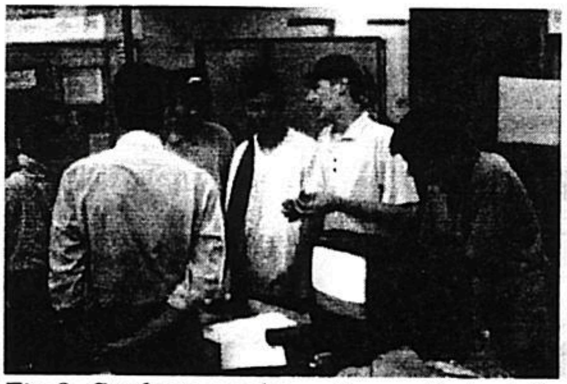

Fig.8. Students explains the project at the "Young Scientist" congress.

It is quite interesting to see the experience the members get from outreach activities. Each year the group participates with a booth in an international Agriculture trade show that happens in Londrina. The members turn themselves during the show attending the booth that calls to much all age public attention.

Fig. 9. GFE booth at agricultural trade show.

Experience in given press information is gained also as both television and printed media covered many launches and abroad events participation. Usually they are a little reluctant in giving interview for the TV, but soon they discover that is not so difficult.

One of the goals of the group is also to attend whenever is possible in international events. The group and two members participated respectively in a French and a North American launch campaign. The last international participation was at the UNISPACE Congress at Vienna in 1999. The language barrier is a problem but the students overcome this with relative success as the goals are the same and they have a basic common technical vocabulary.

THE NATA

Through the outreach activities and the member's presence in a local State university called "Universidade Estadual de Londrina" – UEL, some teachers created a group within the university called NATA – "Núceo de Atividades Espaciais".

The NATA goals are similar of the GFE and can be the begging of an aerospace institute. The NATA's first project is an experimental rocket with a 12 Kg weight and an 2000 m estimated altitude. It will carry a data logger to measure the rocket rotation and a camera to take different flight phases pictures. It will have a modern composite propellant motor and dual stage recovery.

Nowadays the NATA have 9 students from Civil and Electronic engineering course oriented by 6 teachers divided in different project parts.

Fig. 10. The NATA team before a motor test.

CONCLUSION

A Brazilian 12 years hand's on experience in space education was described The benefits for the students in a space hand's on project are many and makes them find, reassure or direct their future carriers and makes them develop special virtues as profession passions, team work attitudes and problems multidisciplinary view ,just to mention some.

It was described the activities and the GFE and NATA structure with an emphasis in the perceived benefits.